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The Border Star 85 Survey:

TOWARD AN ARCHEOLOGY of LANDSCAPES

edited by
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The archeological survey for the Border Star 85 exercise was conducted to obtain information about cultural resources that could be used for National Register evaluation. 1.26 sq km were surveyed and 1839 archeology sites were identified. These sites ranged in age from the Paleo-Indian period to Historic times.

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THE BORDER STAR 85 SURVEY
Toward an Archeology of Landscapes

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EXECUTIVE SUMMARY

This final report documents the results of a cultural resources survey program conducted on White Sands Missile Range and Bureau of Land Management land in New Mexico by the Office of Contract Archeology, University of New Mexico for the US Army Engineer District, Ft. Worth as Contract No. DACA63-84-C-0215. The results of an associated monitoring program implemented under separate contract with White Sands Missile Range (Contract No. DAAD07-85-M-1656) are also included in this report. The survey was carried out over 225 sq km (87 sq mi) in the southern Tularosa Basin of south-central New Mexico to facilitate compliance for the U.S. Army Readiness Command Border Star 85 military exercises.

The primary objectives of the suvey program were to conduct a systematic 6 percent sample survey of selected staging areas to obtain information about the cultural resources, which could be used to evaluate the potential eligibility of these resources for inclusion in the National Register of Historic Places, according to the criteria, regulations, and guidelines that pertain to Sections 106 and 110 of the National Historic Preservation Act of 1966 as amended. Fieldwork was carried out in two phases. Phase I, which involved a systematic 6 percent sample inventory of 225 sq km, was begun in October, 1984, and was concluded in January 1985. Phase II entailed an intensive survey and infield analysis of all features and artifacts for six sample quadrats encompassing 1.26 sq km. In all, a total of 1839 archeological site locations ranging in age from Paleoindian to Historic were located by the survey. This final report documents the goals, field data recovery methods, analytical procedures, and results of the project.

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Robert Burton and Peter Eidenbach served as Corps of Engineers managers for the project during the fieldwork and analysis phases, and Gary DeMarcay managed during the last throes of report production for the Corps. Others who materially contributed to the project by engaging us in a productive and spirited debate over concepts and methods include Roger Anyon, Eileen Camilli, David Carmichael, Glen DeGarmo, James Ebert, Robert Hard, David Kirkpatrick, and Karl Laumbach. Finally, we wish to especially thank those who helped in editing, word processing, graphics, and report production during the course of the project: Phillip Arnold, Barbara Daniels, Michael J. Berman, Sheryl Jones, Donna Lasusky, Mary Sue Laurel, Don Leister, Barbara Munford, Lenora Olson, Margaret L. Ortiz, Mary J. Piper, Matthew Schmader, Earnest (J.G. Mulefoot) Shearin, Ronald Stauber, and Fiona Urquhart.

Our thanks to all mentioned here. For Pete and other relics from the HSR team of 1972-73.

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Chapter 1

OVERVIEW OF THE BORDER STAR 85 PROJECT

Richard C. Chapman

The Border Star 85 cultural resources survey project was conducted by the Office of Contract Archeology, University of New Mexico (OCA) to facilitate compliance for the U.S. Army Readiness Command Border Star 85 military exercises. The exercises, which involved over 4500 troops and over 1500 vehicles, were conducted during March, 1985, on White Sands Missile Range (WSMR) and adjacent portions of Bureau of Land Management (BLM) lands in the Tularosa Basin of south-central New Mexico (Figure 1.1).

The project was funded by the U.S. Army Forces Command and was implemented under contract with the U.S. Army Engineer District, Ft. Worth (CE). The original contract (let in October, 1984, as No. DACA63-84-C-0215) entailed the systematic sample survey of 210 sq km (81 sq mi) to identify and evaluate the significance of cultural resources that might be endangered by the military exercises. A subsequent modification (No. P00001) increased the total survey area to 225 sq km (87 sq mi); in addition, a monitoring program during road improvement construction was undertaken prior to the Border Star 85 exercise as a separate contract with White Sands Missile Range (Contract No. DAAD07-85-M-1656). In all, 1839 archeological site locations were identified as a result of the Border Star 85 project.

The Border Star 85 study area is located in the southern portion of the Tularosa Basin, a large, internally drained depression bounded on the east by the Sacramento-Hueco mountain chain and on the west by the San Andres-Organ-Franklin chain (Figure 1.1).

The project area occupies 225 sq km (87 sq mi) in portions of Townships 19, 20, 21, and 22 South and Ranges 7 and 8 East on the Tres Hermanos SW, Tres Hermanos SE, Elephant Mountain, and Orogrande North USGS 7.5 minute quadrangles, Otero County, New Mexico (Figure 1.2, Figure 1.3 in end pocket).

The Border Star 85 cultural resources study involved two stages of fieldwork. The first phase was conducted prior to military exercises and consisted of a systematic transect-based sample survey of the entire 225 sq km project area. The purpose of Phase I was to collect data to be used as a basis for compliance with the National Historic Preservation Act of 1966, the National Environmental Policy Act of 1969, and other federal legislation and regulations pertaining to cultural resources. In addition, the cultural resources data collected during Phase I were used to choose specific areas for investigation during a following, intensive survey phase. Phase I provided for detailed in-field analysis of all cultural material and features falling within a regular grid of 33.33 m long by 2.0 m wide transect recording units (TRUs) spaced 33.33 m apart, and for the recording of locational information for archeological sites on 1:3000 aerial photo enlargements. The combined area of the surveyed TRUs represents an approximate 6 percent sample of the project area. A total of 1809 sites were recorded during the Phase I survey.

Phase II survey, conducted after the completion of the Border Star 85 exercises, was concentrated on six target locales representing a combined area of 1.26 sq km, or about one-half of one percent of the total project area (Figure 1.3). The Phase II effort was intensive, involving an in-field analysis of all cultural materials observed within each parcel using a 2 m by 2 m grid system. Exposed hearths and other features indicating the use of fire were excavated in order to recover radiocarbon samples, and their locations were plotted on 1:750 aerial photo enlargements. Thirty-nine sites were defined within the six parcels, of which nine had been discovered previously during Phase I.

An important aspect of the Border Star 85 project involved efforts to avoid damage to archeological sites during the course of military exercises. This required additional survey, testing, and monitoring activities at access routes and staging areas. A post-exercise damage assessment (Eidenbach 1985) indicates that damage to archeological properties was minimal. Major credit for the successful avoidance of damage to the sites during the large-scale military maneuvers is given to the White Sands Missile Range Environmental and Natural Resources Office, maneuver damage control team (Robert Mitchell, Environmental Coordinator) and the Third Armored Cavalry Regiment, Fort Bliss (Colonel Naylor, Commander).

This two-part document represents the final report of findings of the Border Star 85 project. The first part outlines the overall project objectives, design, and methods (Chapter 2), provides an overview of relevant environmental and archeological background information (Chapters 3 and 4), and summarizes major research results in Chapters 5 through 8. Chapters 5 and 6 focus upon theoretical and methodological concerns related to the use of nonsite data from Phase I survey, while Chapters 7 and 8 describe the results of the Phase II survey effort and attempt to answer the main research questions of the project. The final chapter of Part I (Chapter 9) presents a summary of project results and recommendations for future research.

Part II presents findings from a variety of specialized studies that focus on materials collected during one or both

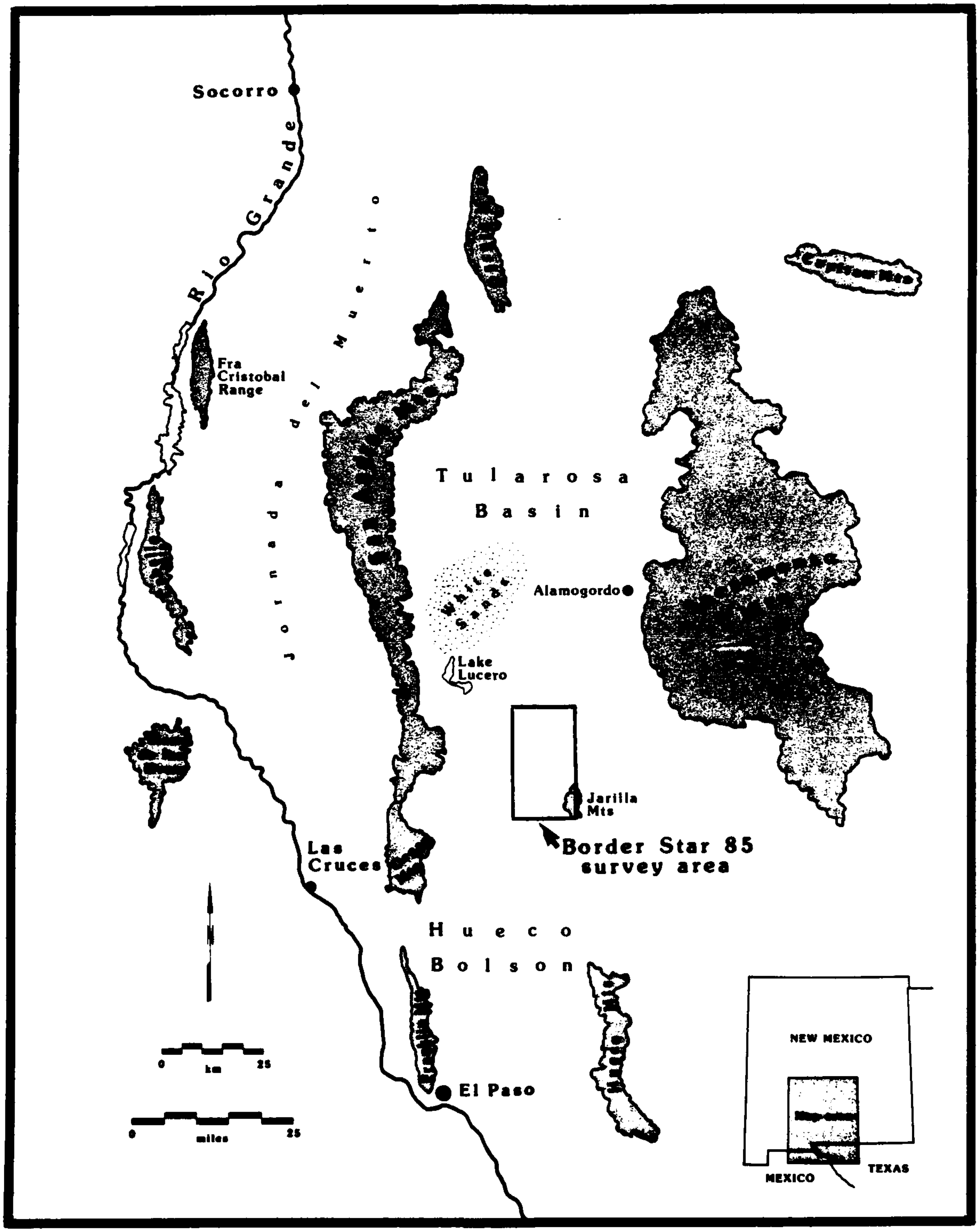


Figure 1.1. Location of project area in New Mexico

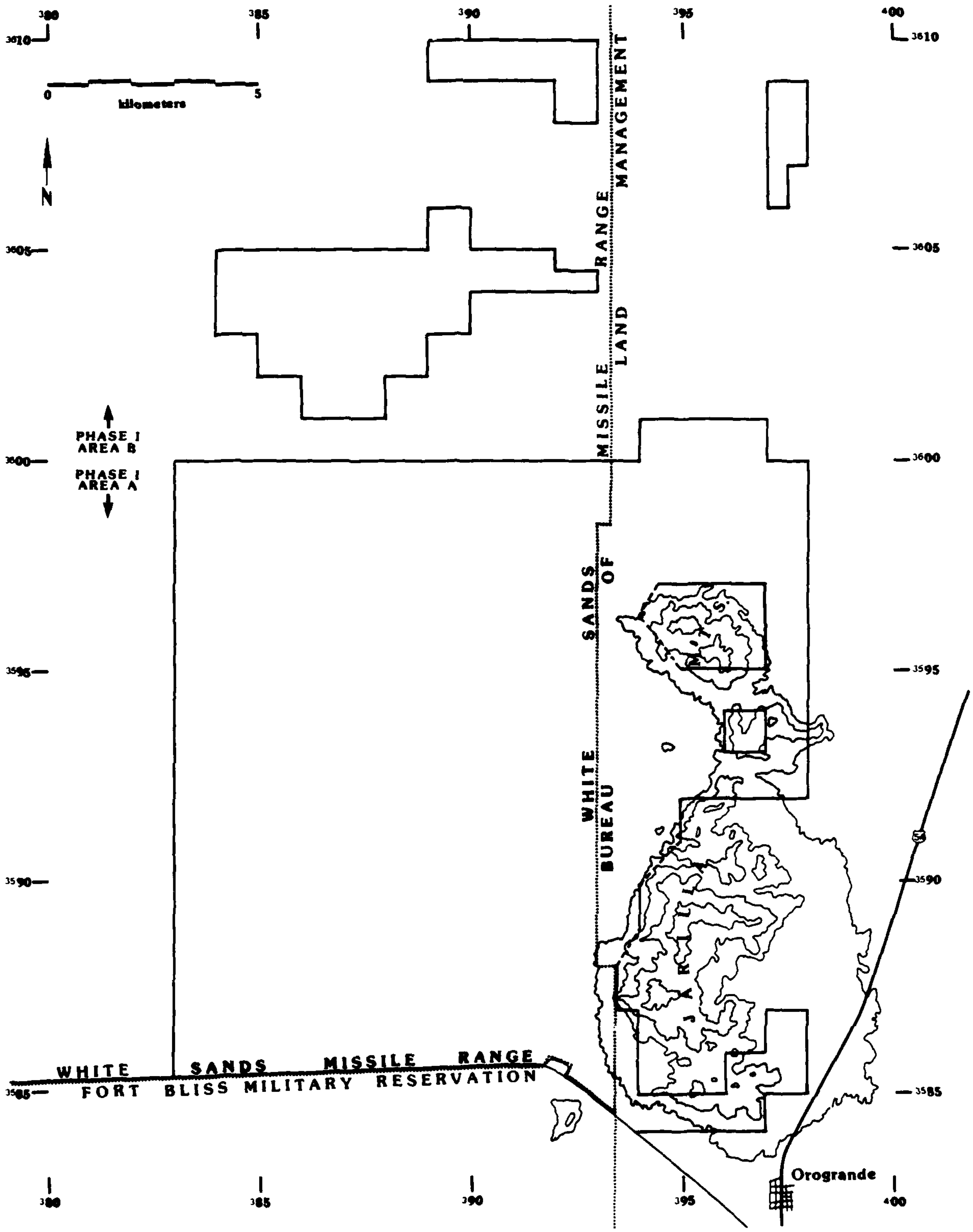


Figure 1.2. Location of the Border Star 85 Survey areas

survey phases. Chronological concerns are addressed in the first four chapters of Part II. The results of radiocarbon dating studies and charcoal identifications are considered in Chapter 10, and obsidian source identifications and hydration dating results performed by the Obsidian Hydration Laboratory at Eastern New Mexico University appear in Chapter 11. The ceramic typology used in dating Formative period assemblages is outlined in Chapter 12, and Chapter 13 presents the results of investigations focusing on the use of El Paso Brownware rim sherds as an additional ceramic dating method in the Jornada region. The remainder of Part II presents the results of four technological studies of the Border Star 85 ceramic and lithic collections. Petrographic analysis of a sample of collected Mimbres Black-on-white sherds is documented in Chapter 14. Lithic analyses include a statistically oriented typological study of projectile points (Chapter 15) and a functional analysis of other lithic tools collected during Phase I survey (Chapter 16). Finally, an assemblage of tools collected from a large Paleoindian site (LA 63880) is described in Chapter 17.

Appendices relating to Part I include survey procedures (Appendix 1); data processing guidelines (Appendix 2); site data summaries from Phase I survey (Appendix 3); notes on the geology and mineral resources of the Jarilla Mountains (Appendix 4); and data concerning features and artifacts documented by Phase II Survey (Appendix 5). Appendices to Part II include results of the monitoring program (Appendix 6); a list of non-military, historic artifacts and features discovered during Phase I Survey (Appendix 7); El Paso Brownware Rim data (Appendix 8); data from petrographic analysis of Mimbres Black-on-white ceramics (Appendix 9); plates of projectile points collected during Phase I survey (Appendix 10); and lithic tool data from site LA 63880 (Appendix 11).

For the Office of Contract Archeology, the Border Star 85 project has constituted a milestone on several fronts. It has affected the manner in which we have conceptualized human behavior as it relates to the formation of the archeological record and, equally, the manner in which we have gone about describing and analyzing that record.

Although conventional wisdom holds that method follows theory in archeological research, the Border Star 85 project has demonstrated that the development of method and theory is an interrelated process wherein methodological parameters have forced us to re-evaluate critically certain tenets of conventional theory. Such re-evaluation has required adjustments in data collection methods.

The methods used for the Border Star 85 survey were essentially thrust upon us as a condition of competing for the contract (and accepting it once awarded). Basic elements of the survey method had been developed by personnel at Fort Bliss, Texas (including Glen DeGarmo, Robert Hard, and Ray Mauldin), and reflected an outgrowth of more than a decade of experience in managing archeological and historic properties on that highly active military installation.

Some of these methods, such as the routine use of aerial photographs to document locations of artifacts, features, and site locations, had evolved during the course of previous large-scale inventories on Ft. Bliss lands and had been used on previous OCA projects when such imagery was available. Others, such as the rigorous restriction of survey observations to predefined Transect Recording Unit boundaries and the post-facto statistical definition of site boundaries using only those TRU observations, were frankly experimental in approach, and had not been previously field-tested for their analytical efficacy. Finally, the constraint that *all* data be computerized as they were generated, i.e., during the course of fieldwork and not after, necessitated a major logistical overhaul of our previous approach to processing and analyzing archeological survey data.

We believed that the analytical import of some of these methodological concerns could be readily identified at the outset of the project, and these concerns were treated in our proposal offered in response to the solicitation. Issues of appropriate transect interval spacing as they related to the statistical reliability of analytical results were dealt with in detail, as were strictly logistical concerns, for example, whether to use lap-top computers for on-line data entry during survey.

Some of these issues, such as the use of paper field forms rather than computers for initial data entry, were resolved (in our opinion) satisfactorily. On other issues, such as the $33^{1}/_{3}$ m spacing between survey transects (perceived by us to be too large), we were unable to argue successfully on theoretical grounds alone for either an overall, survey-wide interval reduction, or even for a reduction of transect intervals for a control sample of survey units. We believe that the analyses in this report using empirical data derived from the survey will clearly demonstrate the limitations of the interval spacing imposed.

A number of other points of methodological discussion between OCA and the CE derived from the original solicitation specifications. Included among these were implications inherent in using unrectified aerial photographic images as base maps for the primary survey locational documentation; the ultimate analytical utility of qualitative and quantitative estimates of off-transect observations made for artifacts and features beyond 5 m if surveyors did not leave their defined TRU to verify each guess directly; and the utility (or wisdom) of trying to use field perceptions based upon first discovery in the assignment of National Register significance to the site locations.

Distortions in aerial imagery were ultimately accomodated by field crews, although the terms "hyperspace" and "hypospace" assumed empirical rather than abstract meaning as crews routinely paced off long and short TRUs at the edges of photo images. Off-transect observations proved to be of some utility for estimating the overall diversity of artifacts, though only within broad parameters. The New Mexico State Historic Preservation Officer determined that field perceptions alone (or indeed the entire TRU method as implemented) were inadequate for rendering determinations of National Register eligibility.

A more critical methodological issue that constituted a primary focus of the Border Star 85 project was the eval-

uation of the accuracy and precision of the Phase I systematic sample inventory method. The Phase II intensive survey data were used in this evaluation, with the result that parameters can now be placed on the scale of resolution at which different kinds of data can be reliably used as information concerning archeological distributions on the basin floor. The issue of the assessments of accuracy and precision for data generated from surveys, such as the Border Star 85 project, is of critical importance in the comparative use of those data. Although analysis directed toward such an evaluation is not popular at present, the need to undertake these assessments will become obvious in the future as the large-scale survey data now sitting "on the shelf" are increasingly resorted to as primary information in comparative studies. It is our hope that the Border Star 85 project will serve as a stimulus for similar project self-assessment efforts in the future.

Chapter 2

PROJECT DESIGN

Timothy J. Seaman

This chapter introduces key elements of the Border Star 85 project design. It documents the initial formulation of the design, as supplied by the U.S. Army Corps of Engineers, and its evolution over the nearly one and one-half years that elapsed between contract award and the completion of analysis and reporting activities. The basic organization of the project, the methods of data collection and analysis, and the research goals will be outlined here. Because certain aspects of the prescribed survey methods diverge from the "traditional," special attention is given to illuminating the relationship between the methods and the analytical goals.

The Border Star 85 project was conducted according to a design provided by the Corps of Engineers, Fort Worth District. Major portions of the project design were developed by the Fort Bliss Environmental Office; as such, the project represents an extension of research currently being conducted on that military reservation immediately south of the project area. Detailed guidelines for both data collection and analysis were presented in the RFP along with an outline of overall research objectives. OCA responded to this RFP by incorporating these guidelines and objectives in its technical proposal and, as requested, by suggesting several design enhancements. For the most part, these proposed changes consisted of additions to or refinements of the basic methods of data collection and analysis rather than modification of the project design. After a period of negotiation, which concerned the effect of the proposed changes on project goals, scheduling and funding, some of these changes were incorporated in the final project design. These changes are specified below where relevant.

Organization

The project was divided into two phases each of field data collection and laboratory analysis. The Phase I survey focused on the entire project area and was conducted prior to the Border Star 85 military exercises (Figure 1.2 and 1.3). Subsequent analyses of Phase I data were performed in order to provide a basis for compliance-related decisions and to guide the selection of a sample of cultural properties for investigation after the completion of military maneuvers. Phase II survey was more intensive than that conducted in Phase I, but was limited to an extremely small sample of the project area. The laboratory analyses initiated after the completion of these investigations focused on, but were not limited to, data from Phase II and were designed to address the major analytical goals of the project.

Analytical Goals

Formative Period Adaptations

The major research questions guiding the Border Star 85 project concern Formative period adaptations. The RFP presented the basic outlines of two models concerning subsistence and land use during the Late Mesilla (AD 750–1000) and El Paso (AD 1100–1400) phases in the southern Tularosa Basin and Hueco Bolson. These models were developed by Robert J. Hard and Ray Mauldin, respectively, of the Fort Bliss Environmental Office under the direction of Dr. Glen DeGarmo. These models are described and developed in other published and unpublished sources (Hard 1983a, 1984, 1986; Mauldin 1984, 1986).

The Border Star 85 survey was not designed to be a formal test of the validity of these models. The RFP explicitly states:

> This project should be understood to be a preliminary attempt to recognize some theoretically expectable, but as yet undocumented, components of archeological variability thought to exist in the Jornada Mogollon region (Section C; Paragraph 6.1).
>
> Note that the project represents some of the first, but not the only, tests of the models, and it is not expected that the results will document the validity of the models in any final sense. It is expected, however, that the quantitative results developed by this project will be useful for making appropriate revisions in the models (Section C; Paragraph 6.4).

Both models are based on a series of proposals relating Late Mesilla and El Paso phase adaptations to seasonally variable environmental conditions in the southern Tularosa Basin and Hueco Bolson. The adaptative characteristics of interest are regional subsistence (e.g., dependence on wild vs domestic food resources) and land use (e.g., residential vs logistical mobility) strategies as reflected in variability in site location, content, and structure. Predictions are made for both periods regarding these realms of variability for expected site types.

For Late Mesilla populations assumed to be only minimally dependent on agriculture, these site types were created to reflect variability in season of occupation, site function, and use intensity (i.e., summer foraging camps, winter residential villages, fall hunting camps, etc.). Analytical expectations regarding site location, assemblage content, and internal structure relate to seasonal variation in the availability of critical resources within the basins and adjacent highlands. El Paso phase populations are assumed to have been substantially more dependent on

agriculture than those in earlier periods, and the expected site types reflect significantly less residential mobility. Two major site types are anticipated (primary and secondary villages), and detailed expectations regarding site location, content, and structure are similarly provided. The model also anticipates a wide variety of small, logistical or special-purpose sites (seed gathering camps, hunting camps, etc.) on the basin floor and in surrounding mountain areas.

Chronological Analyses

A variety of other analyses mandated in the RFP concerned chronological placement and required both qualitative and quantitative studies of artifacts and other materials. Although obsidian hydration was intended to be the primary chronometric technique for dating sites, a few radiocarbon samples were also to be processed for comparison with the obsidian dates. Ceramic studies were crucial to establishment of chronological control among recorded cultural properties and also to increasing the accuracy of ceramic-based dating methods in the Jornada Mogollon region. Analyses of ceramics involving both standard typological approaches and more quantitative methods were required for recorded or collected artifacts. Additional ceramic studies proposed by OCA included statistical analyses of El Paso Brownware rim forms and, in an effort to resolve ambiguities in the identification of Doña Ana phase (AD 1100–1200) assemblages, petrographic analysis of Mimbres Black-on-white sherds was also undertaken.

Two additional chronological studies proposed by OCA focus on lithic artifacts. The first involves an analysis of the lithic reduction technique as a potential means for temporal placement of otherwise undatable assemblages. Based on previous studies by Chapman (1977), Schutt (1983), and others, this line of inquiry starts with an effort to identify patterned variability in reduction techniques across a sample of temporally identifiable assemblages. These patterns are then compared with data from unknown assemblages. The method, sensitive only to changes across very broad temporal periods, is aimed at the separation of aceramic Formative period sites from Pre-Formative sites rather than assignment of assemblages to specific phases.

The second study consists of comparative analysis of projectile points collected during the Phase I survey. At present, the use of projectile point typologies in Tularosa Basin research provides a very tenuous means of chronological control. The proposed study is designed to compare the Border Star 85 projectile points to the existing typologies for the Oshara, Cochise, and Trans-Pecos traditions and to provide accurate, usable descriptions and illustrations of these artifacts for future research.

Identification Problems

Another analytical concern mentioned in the RFP involves consideration of current ambiguities in the identification and classification of sites in the southern Tularosa Basin during archeological survey. The specific problems can be roughly divided into two groups based on site size. Large or extensive sites with high artifact densities present interpretive problems in that they may represent either intensively reoccupied, limited activity areas or extensive residential sites. This line of inquiry involves the evaluation of several propositions listed in the RFP that relate assemblage size and variety, site structure, and other assemblage characteristics to site function and occupational history.

Small sites frequently make up a large portion of the total number of sites in the interior basins of the Jornada region, and the RFP specifically requested a proposed analytical model for identifying and interpreting these cultural properties. The strategy proposed by OCA divided the small sites problem into two parts: discovery and interpretation. The discovery of small sites during any transect survey was seen as problematical from a sampling point of view; this problem was approached through proposed enhancements in data collection and a comparative analysis between Phase I and Phase II survey results. The interpretation of small sites was viewed as an effort to understand their organizational role within the adaptative systems of which they were a part. It was proposed that the functional analysis of small sites be approached using assemblage data collected from a sample of dated small sites during the Phase II survey. Only a few of the proposed changes in data collection that would have supported these analytical approaches were approved by the Corps of Engineers.

Settlement Patterns and Environment

Finally, the RFP specified that settlement patterns during all identified cultural periods be considered in light of environmental features of the Border Star 85 project area. Specifically, these features include a series of broadly defined environmental zones (i.e., desert floor, alluvial fans, and mountains) and hydrological features, such as ephemeral playas on the basin floor and drainage networks along the alluvial fans. Survey results from both phases of survey were to be correlated with these environmental features in terms of site function and period(s) of occupation.

Phase I Data Collection

The Phase I survey was conducted over the entire 225 sq km project area (Figures 1.2 and 1.3). In order to facilitate the compliance process within a very short time frame, Area A was surveyed prior to Area B, and a preliminary compliance report was prepared for each area. Although several minor changes in data collection methods proposed by OCA were incorporated into the project, the Phase I survey procedures were followed largely as outlined in the RFP. All forms, variable definitions, and codes utilized during Phase I are included in a survey guide (Appendix 1). This document was developed during the five-day training session attended by all members of the survey crew prior to Phase I. Although minor adjustments in procedure were made throughout the survey, the reader is referred to the survey guide and the accompanying recording forms for detailed information (Appendix 1).

Survey Coverage

The Phase I survey crews used 1:3000 scale diazo enlargements of uncorrected aerial photographs. Each of the 60

maps encompassing the Border Star 85 project area covers an area ca. 2.5 km on a side with a small amount of overlap on adjacent maps. A matrix of UTM grid coordinates interpolated from 1:25,000 topographic maps was drafted by the CE over mylar copies of the aerial photo enlargements. These square kilometer Survey Units (SUs), identified by their UTM coordinates, were used as basic units of survey coverage and record-keeping throughout Phase I.

Although imagery distortions often fostered confusion in the field, the alternative of using 7.5' USGS topographic maps in the featureless basin floor would have resulted in far greater confusion. Difficulties most frequently arose when transect lines failed to match up with those of adjacent maps. Conventions for handling these nonalignments were developed and adopted by the survey crews with some success. In most parts of the survey area, predetermined transect lines could be located and followed using vegetative patterns as a guide, and site boundaries were plotted accurately.

On-the-ground survey was guided by a grid of north-south transect lines spaced at 33.33 m intervals and subdivided into 33.33 m long segments. These segments served as the basic unit of data collection during Phase I. The Transect Recording Unit or TRU consisted of an area 2 m wide along the 33.33 m long segments in each transect line. Thus, each square kilometer SU contained a grid of 900 TRUs, resulting in a total of 202,500 TRUs for the 225 sq km project area. Translated into the actual area of intensively surveyed space (i.e., within-TRU area), the latter figure represents a 6 percent sample of the total survey area. Figure 2.1 illustrates the numbering and arrangement of TRUs within a hypothetical SU, and a copy of a sample photo enlargement is included in Appendix 1.

Within each SU, survey was performed by a three-person crew walking adjacent transect lines. From the center transect, the crew chief was responsible for maintaining the position and spacing of the crew within the TRU grid and recording the TRU coordinates. Each crew member was responsible for recording information within his or her transect; however, in situations where artifact density was high, it was most efficient to use the entire crew to assist in the recording of data. Six survey crews were utilized during Phase I.

Data Recording

During survey both qualitative and quantitative data were recorded within and outside TRUs. Four kinds of information were recorded within the TRU:

1) Artifact attribute information and counts for ceramic and lithic items within the 2 m wide TRU.
2) Information concerning the types and gross size and density attributes of features and artifact distributions observed in or near the TRU.
3) Environmental data (topographic situation and vegetative characteristics) at 100 m intervals.
4) Clerical information related to the TRU itself and the circumstances of observation.

Within each TRU, artifact attributes were coded for chipped and ground lithic artifacts. For lithic tools these included artifact type (flake, core, mano, etc.), completeness, generic material type (chert, obsidian, sandstone, etc.), and size in two dimensions. Attributes such as platform type (single facet, collapsed, prepared) and amount of dorsal cortex were also recorded for lithic debitage. Ceramics within TRUs were counted according to the typological scheme described in Chapter 12. Off-transect artifacts were recorded as lithic or ceramic scatters containing an estimated number of artifacts.

Type, size, density, and location of features such as exposed hearths or fire-cracked rock concentrations, architectural features, and historical remains were recorded. Small features were located on a scaled sketch map of the TRU and adjacent areas, while architectural features and very dense artifact concentrations were identified directly on the photo enlargements.

At 100 m intervals along the transect, crew chiefs collected information on landform, using standard NM Archeological Records Management System codes, and dominant vegetation. The latter information was collected using an angle gauge, which provided ground cover estimates in percentages for the dominant shrub species. Also, the locations of playas, arroyos, vegetative anomalies, historical remains, and less obvious modern features were marked on the photo enlargements. Thus, 100 systematically spaced environmental observations were made for each square kilometer in the project area.

Collections

Collections were made during survey, mostly in order to provide artifacts for special studies. Although exceptions were made to this policy at the request of the Contracting Officer's Representative, all projectile points, obsidian artifacts, unknown intrusive ceramics, and "rare" artifacts were collected. The latter category was interpreted rather conservatively and was largely limited to ornaments and the like. Within TRUs, all rim sherds were collected, as were retouched lithic artifacts.

Archeological Site Definition

The RFP mandated that sites would not be defined during transect survey. No provision was made for recording information about sites. All recorded data referred only to the 33.33 by 2 m Transect Recording Units. No site forms were filled out, no sketch maps were made, and there was no provision for narrative descriptions or sampling for assemblage content other than through the fixed registration grid of TRUs.

This situation was responsible for a considerable amount of confusion during project implementation and has had serious effects on project results. The stated purpose of the Phase I survey was as follows:

> Phase I will be conducted for the purpose of discovering sites, mapping their locations, making preliminary determinations of site area, and recording general observations about site characteristics (Section C, Paragraph 8.3).

Although the purpose of Phase I was the recording of sites, the basic approach to data collection was nonsite rather than site-oriented. The RFP specifies that the definition of archeological sites is an analytical rather than a data collection task and that "relative" definitional criteria be developed and applied:

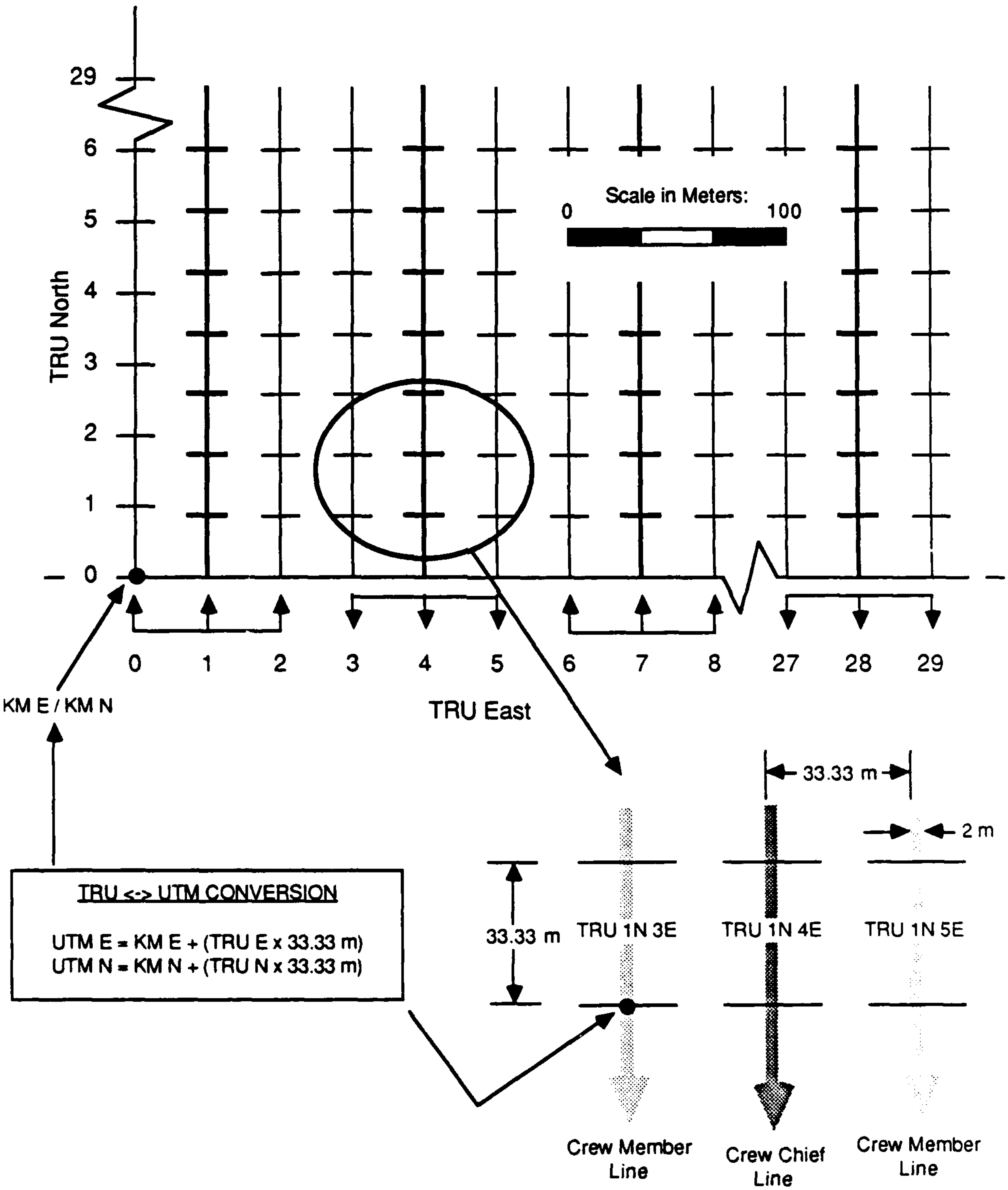


Figure 2.1. Phase I TRU survey methods

> Sites will be defined in the laboratory using the quantitative and qualitative data recorded during Phase I of the project. No strict quantitative criterion . . . will be used . . . to define sites (Section C; Paragraph 9.1).

Although contradictory with regard to the stated purpose of the survey and somewhat inconsistent with stated analytical objectives, the prescribed field procedures reflect a desire to define and record archeological *sites* using a systematically collected sample of quantitative and qualitative archeological data from a "cultural landscape."

OCA suggested two adjustments to the survey procedures. Although these changes were proposed in order to implement an investigation of small sites, it was recognized that they would also enable evaluation of the accuracy and precision of the prescribed survey methods in the discovery and definition of sites of all sizes. The first of these proposals consisted of the survey of a 10 percent sample of the project area at twice the intensity; that is, crew spacing and TRU length would be half that of the standard 33.33 m figure. The proposal was not accepted by the CE. The second modification involved the subjective identification of site boundaries on the photo enlargements during survey, an effort which drew on crew experience in order to provide some form of limited ground truth for comparison with analytically defined boundaries. This proposal was accepted by the CE.

Two methods were used to define site boundaries during Phase I. The first and most commonly used method relied almost entirely on in-field observations of artifact distributions during the course of TRU data recording. It involved some off-TRU forays by crew members to determine the spatial parameters of limited distributions, most commonly located in exposed areas between coppice dunes. These inspections were carried out only when cultural debris was observed on or from the TRU.

In many portions of the Border Star 85 project area this observational strategy for boundary definition was found to be inefficient and, in some cases, impossible. The areas studied are characterized by continuous artifact distributions ranging from low-density scatters of artifacts and hearth features to very dense concentrations suggestive of intensely occupied habitation sites. In such cases, graphic representations of "cultural" TRU densities were used to outline the limits of these distributions (Appendix 1). Using this method, archeological sites were, in a sense, "built" using TRUs as additive units. Site boundaries were determined graphically, by applying a series of rules that take both on- and off-transect observations into consideration.

Very early in Phase I, the CE requested that WSMR site numbers be assigned to cultural properties discovered during the Border Star 85 survey and that the associated TRU information be summarized for each property. This information was used in compliance discussions with the State Historic Preservation Officer. Thus, site numbers were assigned after the completion of survey as part of the data processing effort.

Data Processing

As the survey was completed in each SU, all TRU forms, collected artifacts, and site location information were turned over to the data processing crew, housed in Alamogordo. Site locations identified on aerial photo enlargements were transferred to a master set and assigned WSMR site numbers. Site number associations were added to the TRU forms and collections were packaged for transport to OCA. These records were checked for completeness and accuracy and entered into microcomputers. A custom data management and reporting program was developed by OCA for this effort (Appendix 2). After verification, summary statistics for each survey unit were generated and stored within a single master data base for analytical and reporting purposes. At the end of each 10–day field session data records were transported on floppy disks to OCA and transferred to the mainframe computer at the University of New Mexico for further editing and analysis. The data processing effort continued at OCA after completion of Phase I fieldwork and was followed by preliminary analysis in preparation for compliance meetings.

Summary of Phase I Results

A total of 225 sq km were covered during the Phase I survey between October 1984 and January 1985. The area covered is illustrated in Figures 1.2 and 1.3 and is described in Table 2.1. Approximately 222 sq km was surveyed utilizing the standard TRU strategy. The remaining 3 sq km of coverage consisted of more traditional site-oriented survey along existing and proposed routes of travel for the Border Star 85 exercises. The majority of this second type of coverage specified by the Contracting Officer's Representative (COR) focused on BLM-administered lands east of the Jarilla Mountains.

The Phase I survey effort totaled 69 survey days or about 1340 person days. Of this total, 85 person days (6.3 percent) were used for crew training and 106 (7.9 percent) by travel to and from Albuquerque. Thus, a total of ca. 1149 person days (85.8 percent) were involved in actual on-the-ground survey of the 225 sq km area, resulting in an average daily coverage rate of 0.20 sq km/person/day or 3.54 sq km/day for the entire crew of 18.

Owing to a contract modification that added 15 sq km to the original 210 sq km project area, and to a series of unanticipated delays caused by severe weather, sickness, and WSMR evacuations, OCA was unable to complete Phase I survey by the 15 January 1985 deadline. A total of 15 survey days lost to inclement weather and evacuations delayed completion of the survey until 24 January 1985. This amount of down time is significant, as it represents

Table 2.1. Border Star 85 Phase I survey coverage

	Coverage (sq km)
Area A (WSMR)	144.0
Area A (BLM)	49.0
Total (Area A)	193.0
Area B (WSMR)	26.5
Area B (BLM)	5.5
Total (Area B)	32.0
Total BS-85 Area	225.0

more than 23 percent of the originally proposed 65–day effort.

The results of Phase I survey are summarized in Table 2.2 and TRU data from the defined sites are described in Appendix 3. During the Phase I data processing effort almost 32,000 records were entered and edited. After transfer to the mainframe computer, further editing was completed, and a number of analytical data sets were created. A total of 318 person days, or approximately 18 percent of the total Phase I effort, were expended on data processing activities. Initial estimates by OCA of the intensity of this effort were found to be inadequate in terms of both personnel and required hardware, and it was necessary to double the size of the data processing staff and the number of microcomputers.

Phase I Analysis

The analysis of Phase I data had three objectives. First, TRU data were to be used to define archeological sites. As was outlined briefly above, the actual methods and definitional criteria used in this analysis were only generally specified in the RFP and were to be negotiated during Phase I. In this regard, OCA proposed to rely primarily on cluster analysis and isopleth mapping techniques. The second objective was to provide a basis for the "removal" and protection of a sample of sites representative of all cultural periods and site types from the Border Star 85 exercises. The RFP specified that it would be impossible to protect randomly chosen (and spatially separated) members of such a sample during military exercises, and that contiguous areas or districts containing the target sites must be chosen (Section C; Paragraph 9.2.2). The RFP also specified that statistical procedures were to be used in choosing these samples for protection unless different requirements were set by the State Historic Preservation Officer or the Advisory Council on Historic Preservation (Section C; Paragraph 9.2.1.). Finally, as a third objective, Phase I analysis was to provide a basis for choosing sites for intensive documentation during Phase II.

This plan simply did not work. In spite of the increased effort in data processing during Phase I fieldwork, the amount and complexity of the TRU information was overwhelming, and it became obvious early in the survey that the analytical definition of sites could not be completed prior to compliance deadlines. It was decided by the COR that the subjectively defined sites would serve as the de facto units of management for the Border Star 85 project. Also, negotiations among representatives of WSMR, the CE, and the State Historic Preservation Officer resulted in a very different plan for compliance that stressed protection of all cultural properties rather than the proposed removal of a statistically defined, representative sample of sites. This decision was based largely on the fact that Phase I site information was deemed inadequate by the SHPO for any evaluation of significance or for determination of eligibility to the National Register of Historic Places. In the absence of adequate information, all cultural properties were deemed potentially significant, and a full avoidance policy for the military exercises was successfully enforced by WSMR.

Table 2.2. Summary of Phase I survey results

Total TRUs surveyed	202,500
Total TRUs with cultural materials	11,484
Total TRUs associated with sites	5,223
Total vegetative/topographic observations	21,470
Total recorded sites	1,809
Total recorded features	14,835
Total recorded lithics	16,274
Total recorded ceramics	19,229
Total recorded artifacts	35,503
Total collected lithics	1,076
Total collected ceramics	558
Total collected artifacts	1,634

Because Phase I was designed as a nonsite survey and the recording of sites was, in a very real sense, incidental to its primary data collection strategy, it is not surprising that site data were considered inadequate for determinations of National Register eligibility. As will be illustrated in Chapters 5 and 6, fixed registration, systematic transect sampling is a very poor means of collecting reliable information when the target population is spatially clustered—as is the case for most archeological sites. This sampling problem is especially acute for small properties, which make up the vast majority of the Phase I sites. Typically, these sites are represented only by one or two TRUs containing fewer than 10 analyzed artifacts, and a significant number of sites are known *only* on the basis of off-TRU observations. For small sites, then, very little is known about the functional or temporal implications of their contents. Those properties with larger numbers of TRU samples are, by definition, more extensive and are probably multicomponent sites. In these situations chronological and functional information is meaningless without a method of segregating assemblages spatially, and it is probably safe to say that TRU data are inadequate in this regard, as well.

Based on initial analytical results, it was apparent that the Phase I data were not appropriate for guiding the Phase II investigations in the manner outlined in the RFP. There was no question that the existing data were unreliable as a basis for choosing Phase II sites using either functional or temporal criteria, and many questions also arose concerning the potent[illegible] "raw" TRU data to provide a basis for the analytical definition of sites. Because quantitative data are required for both cluster analysis and isopleth mapping techniques, only the observations made *within* the TRUs could be profitably used in site definition. The combined area within TRUs represents a 6 percent sample of the total 225 sq km project area—a very small sample in any estimation.

Furthermore, given the 33.33 m spacing of transects, it is likely that a large number of "mixed" assemblages would be generated, and that sites smaller than 100 m in diameter could not be defined using these analytical techniques. The majority of the subjectively defined Phase I sites are even less than 100 m in diameter, so it is rea-

sonable to assume that these properties would be combined into artificially large units with temporally and functionally mixed assemblages. Finally, the costs of such an undertaking in terms of both computer and human resources would severely restrict any such experimentation.

These problems with site definition constitute a major drawback in that the analytical definition of sites is far from being an established or even a tested procedure in the southern Tularosa Basin. Although the Border Star 85 survey methods are in some ways similar to those used on previous surveys at Fort Bliss (e.g., Carmichael 1983), this is, to our knowledge, the first attempt (on this scale) to define sites on the basis of nonsite data.

In terms of selecting areas for Phase II intensive survey documentation, OCA was thus faced with two choices: (1) using site assemblage data in the selection, and accepting the demonstrably inadequate character of those data, or (2) using the entire body of nonsite data as a basis for the selection of target areas, and developing new methods for analytically characterizing the survey universe without recourse to conventional assemblage expectations. After the preparation of a formal proposal for Phase II, and after several stages of negotiations with representatives from the CE and the Fort Bliss Environmental Office, the former was rejected in favor of the latter, nonsite approach. With the added methodological questions concerning the reliability of TRU data and of nonsite approaches in general, the task then became one of choosing *areas* rather than sites for intensive survey.

Phase II Data Collection

The Phase II survey was intended to provide data with which the major analytical goals of the project could be addressed:

> Phase II will be conducted for the purpose of recording more detailed observations on selected samples of sites recorded during Phase I. The Phase II observations are structured to provide data useful for investigating the analytical questions described herein (Section C; Paragraph 8.3.1).
>
> The sites selected for Phase II investigation will be chosen to maximize the potential of obtaining data useful for investigation of the analytical goals and models (Section C; Paragraph 8.3.2).

As will be discussed below, the Phase II sample is very small and cannot be considered adequate for realizing many of the research goals stated in the RFP. Though the choice of areas for investigation during Phase II took the RFP research goals into consideration, the sample derived is by no means statistically valid. The implications of this situation for the results of the Border Star 85 project, and the redefinition of project goals, will be considered in the final section of this chapter.

Sampling Considerations

The choice of Phase II survey units was accomplished through a cluster analysis of TRU data summarized by arbitrary 500 by 500 m units (Chapter 5). Because the RFP restricted Phase II research to Area A (Figures 1.2 and 1.3), the cluster analysis did not consider other parts of the project area. Clustering criteria consisted of statistical summaries of TRU data from each 500 by 500 m unit. Included here are data summarizing the total number of TRUs containing cultural material, estimates of artifact and feature density, and summary statistics regarding similar characteristics for the subjectively defined Phase I sites in each unit. The cluster analysis isolated 18 statistically defined landscape classes and the selection of Phase II survey units was made using these types as a guide.

The work effort allocated for the Phase II survey was contractually limited to less than 10 percent of the Phase I effort (ca. 130 person days). Given the intensive survey methods used, Phase II data were collected for six survey units totalling 1.26 sq km (Table 2.3), or 0.6 percent of the total project area. Since a statistically valid sample of land area could not be surveyed during Phase II, the choice of particular survey units was essentially subjective, but was guided by a desire to crosscut the full range of variability in landscape types as defined by the cluster analysis, as well as temporal/cultural and environmental factors. With one exception, the selected units measured 500 by 500 m. A single 100 by 100 m unit was selected from the Monte Carlo Gap area in order to sample a location with an extremely high artifact density.

Survey Coverage

The methodological questions addressed as part of the Phase II survey required data collection procedures that attempted to gain a 100 percent sample of cultural remains from each selected survey unit. The Phase II data also had to be directly comparable to the Phase I data base, and the level of spatial control had to be relatively fine-grained.

Enlargements of the Phase I imagery at a scale of 1:750 were used to guide intensive survey (Appendix 1). A grid system of 20 by 20 m units was superimposed on these enlargements for spatial control during survey and recording procedures. Although this imagery was subject to the same kinds of distortion as the Phase I photos, the distortion was dramatically reduced by choosing the Phase II units from the centers of the aerial photos. Differences between on-the-ground distances and those on the superimposed grid system were found to vary no more than 1–2 percent and it was possible to identify individual bushes and vegetative patterns in most of the survey units.

Field survey and data recording took place in three stages. The first stage was implemented to discover the major

Table 2.3. Border Star 85 Phase II survey units

Unit	UTM		Coverage (sq km)
1	387000E	3597500N	0.25
2	383500E	3590500N	0.25
3	391500E	3587000N	0.25
4	394000E	3594000N	0.01
5	384000E	3590500N	0.25
6	389500E	3587000N	0.25
Total			1.26

concentrations of material culture and record the less dense remains. After boundaries were clearly marked, a crew of three or four surveyors covered each unit with transect intervals of 5–10 m. When isolated or low-density cultural materials were discovered, the locations of all artifacts were plotted on the aerial photos using a unique identification number, and the artifacts were analyzed. These point proveniences were located within the appropriate grid units after completion of Phase II survey. When concentrations of cultural debris were discovered, the approximate boundaries were marked both on the ground and on the photos before the survey was resumed.

As concentrations were marked by the discovery survey crew, four to eight crew members began recording procedures within these areas by setting up a 4 by 4 m grid system using 20 m grid intersections on the aerial photos as control points. The grid system, formed by a series of 20 m long tapes and ropes divided into 4 m segments with knots and flagging tape (Figure 2.2), is a modified version of one documented by McAnany et al. (1984). After a series of 2 m grid markers was set up between the control points along two opposite sides of the 20 by 20 m unit, the tapes and ropes were moved in leap-frog fashion as data collection progressed. The boundaries of individual 2 by 2 m units were marked within the 4 by 4 m areas using the ropes and tapes as a guide. Some error is inherent in this kind of grid system because of inaccuracies in the placement of control points on the basis of photo interpretation. The presence of the ubiquitous mesquite coppice dunes was also a cause of error. All of these errors rarely amounted to more than 5–10 percent however, and within each 20 by 20 m unit they probably cancelled each other out.

The final stage of the Phase II survey involved the testing of exposed charcoal stains located during the discovery and recording stages in each survey unit. The methods used in the collection and testing of radiocarbon samples are discussed in Chapter 10, along with the results of dating and charcoal identification studies.

Data Recording and Artifact Collection

The basic unit of data collection during Phase II was the 2 by 2 m grid square identified by its east and north UTM coordinates within each survey unit. Data recording procedures were almost identical to the method used during Phase I; the main difference was that the amount of fire-cracked rock and burned caliche within each grid was counted rather than estimated. Variable definitions and codes for lithic and ceramic artifacts and features were also identical to those used in Phase I. Phase I collection policies were retained as well.

Data recording procedures are documented fully in the Phase II survey guide which is included, along with recording forms, in Appendix 1. This document, which contains a brief description of the rationale of the survey, a narrative description of the actual survey and recording procedures, and a list of variable and code definitions, was distributed to the crew and used as a training document on the first day of survey. Because only one member of the survey crew had not been trained during Phase I, and because of the close similarities in recording and analysis methods between Phases I and II, training focused largely on the mechanics of survey coverage and recording within the portable grid system. During this short training period a few minor changes were made to the survey methods as outlined in the survey guide. These changes involved adjustments in collection and recording procedures (e.g., ceramic vessel form was not recorded but all rim sherds were collected) and in artifact flagging procedures during survey coverage.

Archeological Site Definition

The definition of site boundaries took place after completion of field survey, initial data entry, and editing. The criterion used to define boundaries was based on the artifact density cutoff within a matrix of 10 by 10 m grids. The application of this criterion was consistent for all survey units and allowed site assemblages to be separated from isolated remains for analysis. This method is outlined fully in the presentation of Phase II survey results in Chapter 7.

Summary of Phase II Results

A total of 39 archeological sites were defined; only 9 (23.1 percent) of them had been originally recorded during the Phase I survey. A summary of the Phase II survey data collection effort appears in Table 2.4.

A total of 1.26 sq km were intensively surveyed during the 12-day field session in June 1985. Rates of survey coverage varied from 0.04 ha/person day in the densest unit (Unit 4), to 3.57 ha/person day in Survey Unit 1. Overall, the survey had a rate of coverage of 1.14 ha/person day. Phase II survey rates are summarized in Table 2.5.

Analytical Implications

The Border Star 85 data collection methods, as they are specified in the RFP, are poorly linked to the stated preservation and research goals of the project. The research

Table 2.4. Summary of Phase II survey results

Total grids surveyed	315,000	
Total grids with cultural material	4,930	(1.6%)
Unit 1 (62500 grids)	203	(0.3%)
Unit 2 (62500 grids)	616	(1.0%)
Unit 3 (62500 grids)	2,552	(4.1%)
Unit 4 (2500 grids)	1,135	(45.4%)
Unit 5 (62500 grids)	210	(0.3%)
Unit 6 (62500 grids)	21	(0.3%)
Total recorded sites	39	
Total recorded features	2,054	
Total recorded fire-cracked rock	8,085	
Total recorded lithics	10,487	
Total recorded ceramics	8,782	
Total recorded artifacts	19,269	
Total collected lithics	122	
Total collected ceramics	170	
Total collected artifacts	292	

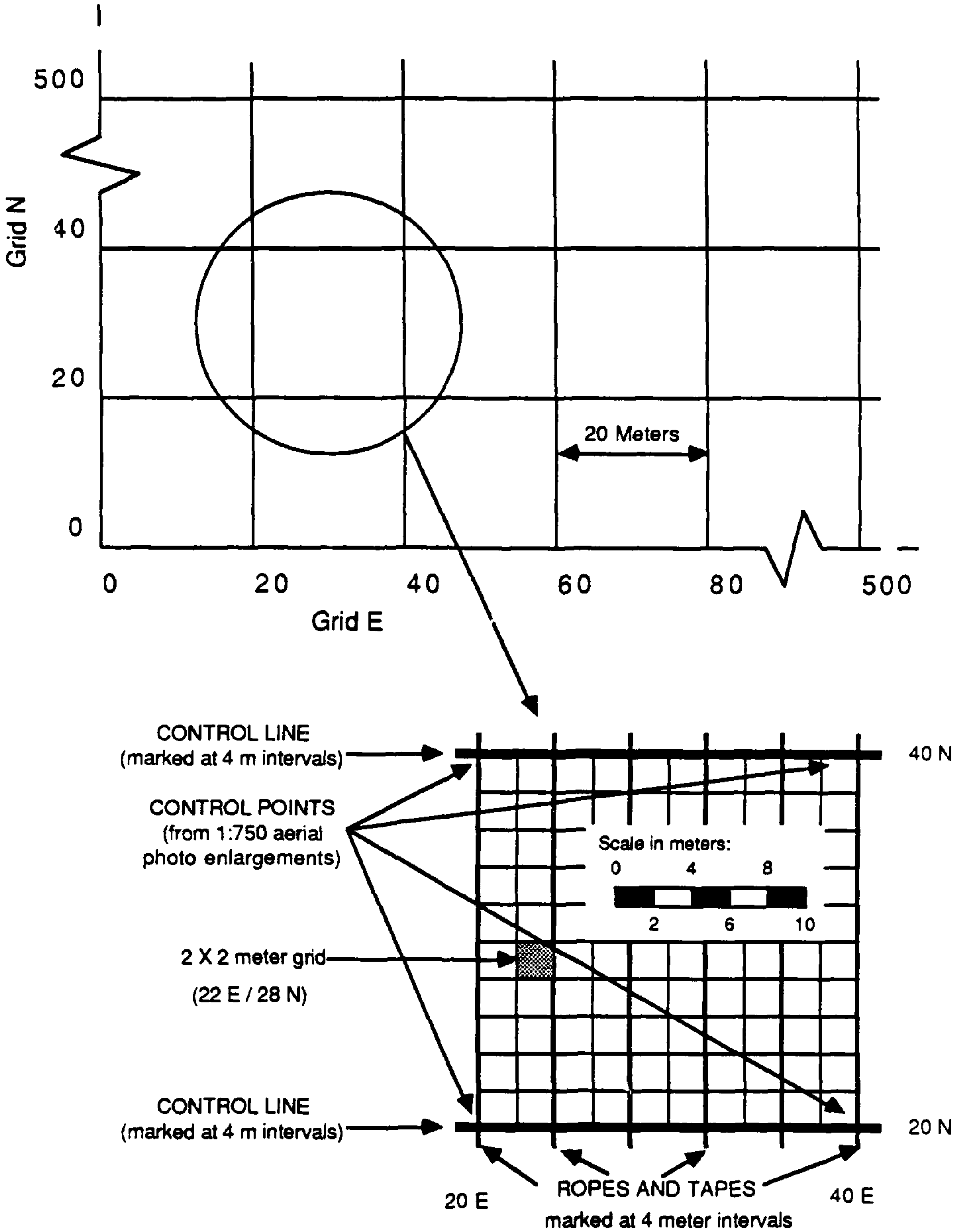


Figure 2.2. Phase II survey methods

Table 2.5. Border Star 85 Phase II survey coverage statistics

Survey Unit	Stage	Person Hours	Person Days	Unit%*	Total%**
Unit 1	Discovery	64	8.0	80.0	
(87E/97.5N)	Recording	16	2.0	20.0	
	Total	80	10.0		9.1
Unit 2	Discovery	62	7.8	44.6	
(83.5E/90.5N)	Recording	77	9.6	55.4	
	Total	139	17.4		15.8
Unit 3	Discovery	60	7.5	17.1	
(91.5E/87N)	Recording	291	36.4	82.9	
	Total	351	43.9		39.8
Unit 4	Discovery	0			
(94E/94N)	Recording	189	23.6	100.0	
	Total	189	23.6		21.4
Unit 5	Discovery	50	6.3	73.5	
(84E/90.5N)	Recording	18	2.3	26.5	
	Total	68	8.5		7.7
Unit 6	Discovery	42	5.3	75.0	
(89.5E/87N)	Recording	14	1.8	25.0	
	Total	56	7.0		6.3
All Units	Discovery	278	34.8	31.5	
	Recording	605	75.6	68.5	
	Total	883	110.4		

*Percent of total unit effort
**Percent of total Phase II effort

questions addressed by the project were originally phased in terms of, and assume the existence of, sites or assemblages of known or estimated cultural and temporal affiliation(s). While the methods originally prescribed in the RFP provided for the analytical definition of archeological sites in order to satisfy these requirements, the approach as prescribed was found to be unworkable. The abbreviated compliance schedule of the Border Star 85 project did not contain adequate time for the processing and analysis of the Phase I survey data in the manner suggested. Further, transect spacing requirements dictated that the minimum diameter of sites that could have been analytically defined using the TRU data is 100 m—a figure much larger than the majority of site sizes defined on the basis of subjective evaluations during survey. Also, many, if not most, of the analytically defined sites would be expected to contain artificially "mixed" assemblages as a function of the low resolution of the TRU data.

Given these concerns, the project was forced to deal with the nonsite TRU data in a way that was not originally intended in the RFP. Having abandoned the strategy of analytical site definition, we had to consider the TRU data as an independent data set; its potential for achieving the stated analytical objectives became a crucial area of inquiry in and of itself. In the process, a number of general questions arose concerning archeological survey as a sampling technique and concerning nonsite approaches in general. These methodological questions became a focus of additional research that utilized the Phase I data as part of its analytical data base and, to a large degree, guided the Phase II data collection effort. This area of research, documented in Chapters 5 and 6, may represent the most important contribution of the Border Star 85 project.

Virtually all of the Border Star 85 analyses were affected by the data collection methods and/or by the very limited Phase II survey effort. Owing in part to the lack of reliably dated Phase I site assemblages, it was not possible to ensure that the data collected during the intensive survey were appropriate to the analytical treatment of the two Formative period models. To wit, Phase II yielded no El Paso phase sites, and it was not possible to consider the model for that period. This was not the intended outcome. At least one Phase II survey unit was selected on the basis of ceramics (i.e., presence of El Paso Polychrome and other diagnostic types), because it contained materials from this period. Based on Phase II analysis of ceramics and/or radiocarbon dating, however, sites defined for this unit were ultimately demonstrated to date from earlier periods. Similarly, sites that appeared to be from the Mesilla phase based on ceramics and TRU data gathered during Phase I were found to date to the Doña Ana phase, or at least had additional, later components. Thus, it was necessary to take some liberties with the Late Mesilla phase model to give it even the minimal attention documented in Chap-

ter 8. The extremely small size of the Phase II sample was also significant in precluding adequate consideration of the two models.

Other analyses hindered by the lack of reliable site assemblage data include chronological studies as well as efforts to assign functional meaning to the Border Star 85 sites. The collection of artifacts and the in-field recording of attributes were completed in order to support these analyses. Studies focusing on ceramic and projectile point typologies, brownware rim studies, etc., were begun immediately after the completion of the Phase I survey in anticipation of creating site assemblage information from TRU observations across the entire survey universe. Usable assemblage data failed to materialize due to the low resolution problems discussed earlier; therefore, most of these analyses of collected items have little direct applicability to problems of prehistoric settlement and subsistence as originally defined.

The reader will also note the absence of analyses that are often expected in more conventional survey projects of this scope. Settlement pattern studies similar to or, more importantly, comparable to those of Carmichael (1983) and Whalen (1977, 1978, 1980) simply could not be pursued using the nonsite Phase I data or the limited Phase II site information. In general, settlement pattern studies attempt to isolate correlations between one or more environmental dimensions and cultural data, in the form of dated site/component locations and estimates of site function based on assemblage data. As temporally sorted cultural data are arrayed against a constant environmental background, the emerging patterns are interpreted as evidence of changes in subsistence, land use, demography, social organization, etc.

Although the data gathering methods employed during Phase I survey precluded these kinds of conventional, site-based settlement pattern analyses, the project did provide a unique opportunity to explore a number of theoretical and methodological issues concerning analysis of human settlement at a scale of landscapes rather than site distributions. We believe these analyses have been productive, and hope that at least a few new directions for future research in the region have been identified.

Chapter 3

ENVIRONMENTAL OVERVIEW

Peter T. Noyes and Matthew F. Schmader

This chapter will outline what is known about the environment of the Border Star 85 project area as part of the southern Tularosa Basin and Hueco Bolson of New Mexico and Texas. The discussions of regional and local geology, geomorphology, climate, hydrology, and biota are presented as background information. The reader is referred to primary sources for detailed environmental information.

Geology and Geomorphology

The Border Star 85 project area covers 225 sq km (87 sq mi) in the extreme southern portion of the Tularosa Basin, New Mexico (Figure 1.2). The Tularosa Basin is the easternmost basin in the Basin and Range Province, which covers most of the Desert West and includes several closed basins on either side of the Rio Grande in New Mexico. The Basin and Range Province was created by the general Rocky Mountain orogeny, which began to raise the Rocky Mountains to the north and the Sierra Madre to the south in the late Pennsylvanian or early Permian period. Locally, the Pedernal Uplift created the Sacramento Mountains and Otero Mesa, and the San Andres Uplift created the San Andres and Organ mountains (Hawley and Kottlowski 1969). As the Pedernal and San Andres blocks rose, the block underlying the Tularosa Basin fell, creating a graben that quickly filled with sediments and the alluvium of the Santa Fe Formation, the latter of which is found in basins throughout New Mexico.

Sedimentary and igneous rocks spanning the Precambrian through Pennsylvanian periods are exposed on both sides of the Tularosa Basin in the San Andres and Sacramento mountains (Denison and Hetherington 1969). Sediments fill the Tularosa Basin to a depth of more than 1000 m (3280 ft). The sides of the basin are characterized by steep alluvial fans and piedmont slopes, which intergrade with playa and sand dune deposits (Figure 3.1).

Throughout Tertiary and Quaternary times the basin has been partially covered by a series of large and small saline lakes. Water-soluble materials, including salts, sulfates, and carbonates, which eroded out of the surrounding mountains, concentrated in these lakes. During drier periods these lakes evaporated, leaving extensive beds of gypsum and salt. The Quaternary (Plio-Pleistocene) Lake Otero reached depths of a few hundred feet (Canover et al. 1955). Lake Lucero, located in the western part of the basin near the San Andres Mountains, is a remnant of Lake Otero.

Across most of the basin floor a continuous eolian sand layer covers the alluvial and piedmont deposits to a depth of more than 90 m (295 ft) (Hawley et al. 1969). The surface of this sand layer is dominated by undulating dunes. Near Lake Lucero, eolian redeposition of gypsum and salts has created the white barchan dunes of White Sands National Monument. Away from the lower part of the basin, less alkaline coppice dunes stabilized by mesquite predominate. These coppice dunes are formed from medium and fine sands by eolian and vegetative processes. The dunes are 1.5–9 m (5–30 ft) high, and larger dunes appear relatively stable and consolidated. Although the dune sand is highly permeable, some rainwater runs into small local playas. After repeated wet and dry cycles, these playas form level, well-drained and stable soils capable of supporting a wider variety of grass and shrub species than the mesquite-dominated dunes (USDA 1981). Playas at the base of alluvial fans fill with fine sediments and create nearly level surfaces, which may evolve into small local grasslands.

The Jarilla Mountains are the most remarkable feature within the survey area (Appendix 4). This small range is 16 km (10 mi) long and 3–5 km (2–3 mi) wide. The mountains rise some 366 m (1200 ft) from the dune-covered basin floor to a maximum elevation of 1615 m (5300 ft). The Jarillas rose during early Tertiary times when, as a result of normal faulting, monzonite and related igneous rocks intruded into middle and upper Pennsylvanian and Permian sedimentary deposits of limestone, dolomite, and shale. As a consequence of the igneous intrusion, metamorphic processes resulted in tactite, garnetite, skarn, and marble (Seager 1961). Iron, copper, tungsten, lead, silver, gold, and other metals can be found along the contacts between the sedimentary and intrusive rocks with such associated minerals as malachite, turquoise, azurite, and limonite. The individual peaks of the Jarilla Mountains are dissected by dry rills and arroyos that lead onto extensive broad alluvial fans. These in turn spill out upon pedimented surfaces, which slope away from the base of the mountains to a distance of some 5 km (3 mi).

Regional Hydrology

Water in the Tularosa Basin is extremely scarce. Running surface water is limited to a few small perennial streams flowing out of the Sacramento uplands between Alamogordo and Three Rivers (Garza and McLean 1977). Soon after entering the basin the streams disappear. Standing surface water is available at Lake Lucero, but the gypsum

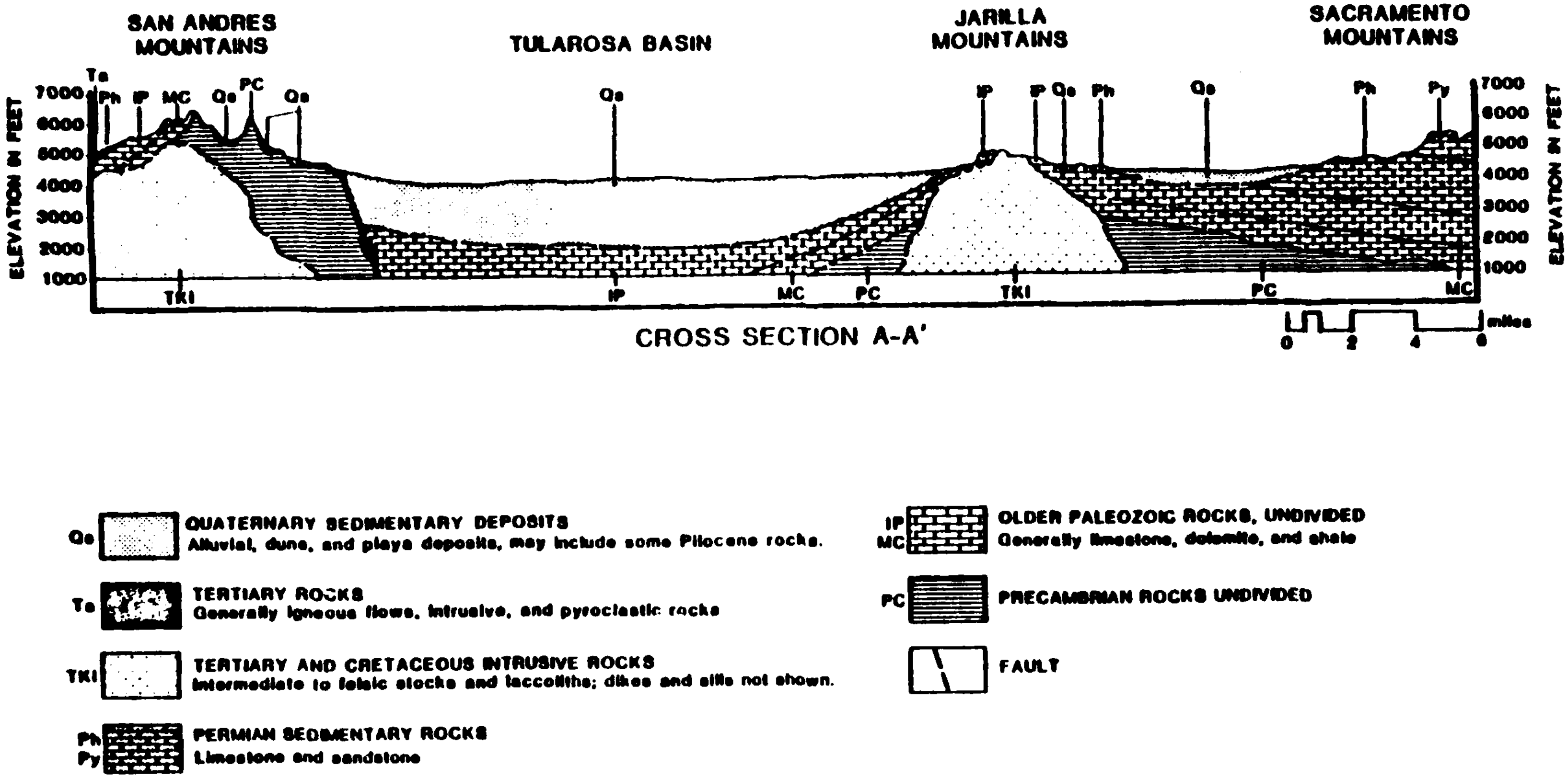


Figure 3.1. Cross section of the Tularosa Basin in the vicinity of the Border Star 85 Survey (adapted from Department of the Army 1985b: Fig. 6)

and salt beds beneath the lake make this water highly unpotable. Local playas provide a potentially important source of water after rainstorms, especially during the summer thunderstorm season. Springs and seeps are few and far between throughout the Tularosa Basin. Some can be found in Permian strata (Yeso and Abo formations) along the faces of the uplifted block faults surrounding the basin. Springs occur in the basin itself at the southern end of the malpais lava flow in the northern part of the basin and at a series of mound formations in Township 10 South, Range 6 East (Appendix 4). The water from these springs cannot be used for irrigation, stock, or human consumption owing to the high level of sulfates and chlorides present in almost all of the subsurface water of the Tularosa Basin.

Precipitation in the basin does not recharge the aquifer. Much of the water percolates into the well-drained sand, but capillary action holds it between the sand grains where it evaporates, leaving a calcium carbonate (caliche) deposit. The resulting impermeable stratum is 1.5–18.3 m (5–60 ft) thick in most of the basin (Department of the Army 1985a).

Recharge of the aquifer is primarily accomplished by diffusion from surface runoff from the elevated areas around the basin. Under the alluvial fans at the base of the mountains the water table follows the contours of the surface, and a "wedge" of fresh water sits on top of the basin water table (Department of the Army 1985a). Water falling on the higher elevations and on the alluvial fans percolates through the unconsolidated alluvium where it is stored in the wedge. As this wedge is recharged with fresh water, a stasis is maintained and keeps the saline water at bay, i.e., down in the basin. In general the water table in the basin is 0.6–90 m (2–295 ft) below the surface, but where arroyos cut into the alluvial fans the water table may be even closer to the present surface (Hood 1959).

Hydrology of the Survey Area

There are few permanent water sources in the Jarilla Mountains. The only known source is a small spring in Water Canyon. The probability that other springs exist, or existed in the past, is high, as the Pennsylvanian "Panther Seep" Formation, which produces seeps in the Organ Mountains, covers most of the northeastern portion of the range. The Panther Seep Formation is a complex, interbedded series of shale beds, marine delta formations, and brackish water clastic rocks. This formation may provide a permeable aquifer capable of producing seeps along faults in steep-sided canyons in the northern Jarilla Mountains during periods of relatively high precipitation (Seager 1961).

The Tularosa Basin is separated from the contiguous Hueco Bolson by the McNew Ridge, which runs from just south of the Jarilla Mountains to the northern end of the Franklin Mountains. This division between the two basins is somewhat arbitrary because the ridge is a surface manifestation not brought about by any major subsurface bedrock structure; the water table is continuous between the two basins (Human Systems Research 1973b).

Because water plays such a critical role in human adaptations, an analysis of the hydrology of the survey area was performed to determine the characteristics of water flow and energy transport of drainages originating in the Jarilla Mountains. The first procedure involved the use of aerial photography at a scale of approximately 1:18,000. This black-and-white aerial imagery was flown by Koogle and Pouls Engineering of Albuquerque in July 1984. Drainages were traced from a set of overlapping photographs and then photographically reduced to overlay onto standard USGS topographic maps at a scale of 1:24,000.

Next, a composite map of the survey area topography was made by tracing contour lines from available USGS 1:24,000 maps. It should be noted that the northern pair of maps (Tres Hermanos and Tres Hermanos SE, 1982) is quite different from the southern pair (Elephant Mountain and Orogrande South, 1955). Although the older southern maps have a 20 ft (6.096 m) contour interval, they provide intervening contours of 5 ft (1.524 m) in the flat portions of the basin at the west end of the study area. The newer northern quadrangles consist of orthophoto mosaics with a 10 ft (3.048 m) contour interval and no intervening contour lines. A pronounced displacement of contour lines occurs at the edges; a number of factors may have contributed to this mismatch, including changes in USGS field methods, use of planimetry vs photogrammetry, or actual changes in the landscape between 1955 and the early 1980s. The predominating wind direction is from the southwest, and contours are generally displaced to the east from the older maps to the newer maps.

Depressions were defined on the basis of contours indicated on the topographic maps. Some of the depressed areas were noted on the aerial photographs by distinct changes in vegetation; however, other such differences did not conform with depressions, and not all depressions could be defined on the basis of vegetation alone. For these reasons, a more objective method of using the USGS map contours was employed.

The above information was compiled in Figure 3.2. Depressions are shaded with broken contour lines at a 10 ft (3.048 m) interval. Normal contours are shown at 20 ft (6.096 m) intervals below the 4400 ft (1341 m) elevation line, and 50 ft (15.24 m) intervals above 4400 ft (1341 m). The modern drainage pattern as derived from the 1984 aerial photography has been superimposed on contours from the 1955 USGS maps. Displacement of the drainage channels can also be seen.

An overall pattern of water flow and energy transport can be derived from inspection of Figure 3.2. Drainages that originate near the divide of the Jarilla Mountains at nearly 4700 ft (1432 m) flow generally to the west and northwest into the survey area. A primary zone of stream energy loss occurs from 4150–4200 ft (1265–1280 m), where the relief begins to yield to more gently sloping alluvial fans. Drainages formed by montane tributaries begin to fan out as sediment load increases and relief or stream power decreases. A second major zone of energy transfer can be detected at about 4140–4080 ft (1261–1244 m), where channels become braided or main drainages begin to split. No appreciable drainage reaches below 4050 ft (1234 m)

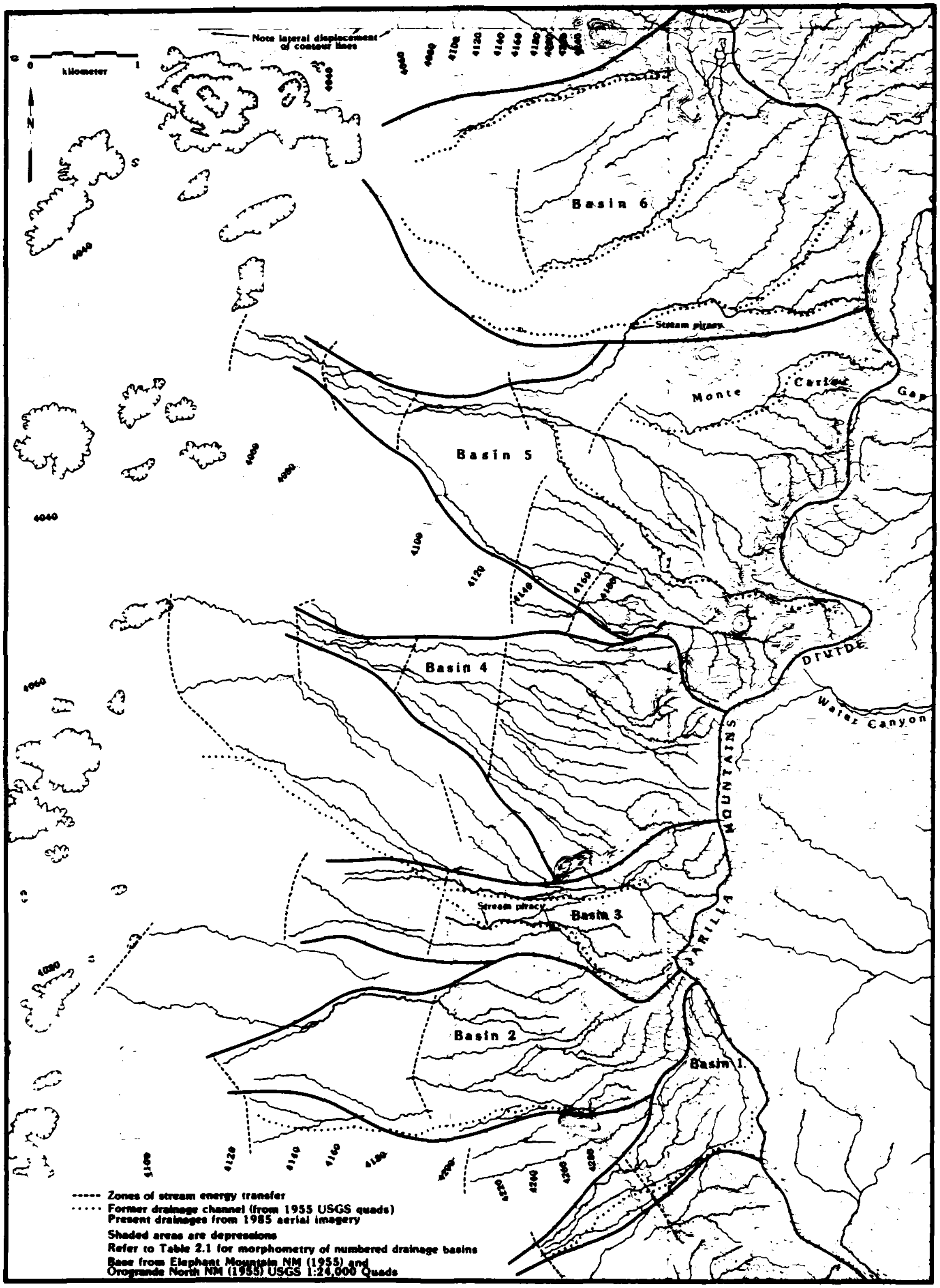


Figure 3.2. Drainage basin characteristics

on the east edge of the basin. The remainder of the surveyed area consists of a basin that drops only 100 ft (30.5 m) from east to west over some 8 km (5 mi). Numerous small depressions and several larger depressions, in addition to associated dune systems, dominate the topography. Most of the depressions are quite shallow, although some approach 20 ft (6 m) in depth and the largest (at the north end of the Elephant Mountain NM 1955 quadrangle) is nearly 30 ft (9 m) deep. A few ephemeral channels appeared to connect some depressions, but none was marked enough to be included in this analysis after inspection of the aerial photography.

Quantitative analysis of landforms has been an underlying principle of geomorphology for at least 40 years. Strahler's (1958) landmark article on fluvially eroded landforms drew upon earlier attempts at quantification (notably Horton [1945]) and established basic measures for characterizing drainage morphometry. Although the expressed purpose for quantifying aspects of stream networks was to compare *similarities* between regional climate or controlling lithology, Strahler's methodology is also suitable for highlighting the *differences* between drainages located in a single regional climate or lithology.

The drainage patterns that were derived from aerial black and white photography were quantitatively analyzed according to many of Strahler's criteria. Six major drainage networks were identified on the western flanks of the Jarilla Mountains (Figure 3.2), and aspects of basin morphometry were quantified for comparative purposes. It should be noted that no analysis related to the determination of stream order was carried out. Although stream order is a vital factor in determining other measures, such as the bifurcation ratio or interbasin area, it does not appear to be well suited for arid environments, where many ephemeral streams are no more than first order drainages and where higher order drainages are braided or can split off into lower order stream segments. In other words, stream order seems to be a measure that was formulated for use on drainage systems more typical of temperate environments, where a regular progression can be followed from small, first-order tributaries to those of increasing stream order and size.

The results of the quantitative analysis of six recognizable drainages in the survey area are summarized in Table 3.1. The drainage basins are numbered sequentially from south to north (refer to Figure 3.2). Area is the size of the drainage basin in square kilometers, from the highest point along the divide of the Jarilla Mountains to the point where no further drainage pattern is discernible. Basin length was measured down the long axis of each drainage network. Basin relief is the difference between the highest and lowest elevations in the basin. Basin perimeter is the length along the exterior divide of each drainage network. Basin circularity is the ratio between the basin area and the area of a circle with the maximum length of the basin. When basin circularity is nearly equal to 1.0, it describes a round basin; the lower the ratio, the more elongated the basin. Relief ratio is the maximum basin relief divided by the maximum basin length. Drainage frequency is the number of distinct stream lengths contained in the basin. Total stream length is the sum of all stream segment lengths contained in the basin. Mean stream length is the total stream length divided by the drainage frequency. Drainage density is the drainage frequency divided by the basin area, yielding a measure of the amount of area between drainages. Relative density is the total stream length divided by the basin area, yielding a measure of the coverage of the basin by the drainage network. Texture ratio is the drainage frequency divided by the basin perimeter and is a relative measure of the texture of the terrain drained by the basin. Higher values indicate rougher terrain and lower values indicate smoother terrain texture.

Basin area, length, and circularity all tend to increase from south to north (Figure 3.2). This is probably a function of lithologic control, since the amount of available relief for potential stream power is fairly uniform across the divide of the Jarilla Mountains. A basin that is more filled with drainages and has a greater amount of effective erosion will be closer to a state of equilibrium than a basin with fewer drainages. This is truer of Basin 5, which drains Monte Carlo Gap, and Basin 4, the system just to the south of Monte Carlo Gap than it is of the other basins. This type of more stable drainage network offers the most agricultural potential in the study area, since the basin type has a greater capacity to capture and transfer water while being less subject to erosion or changes in drainage course. To a certain extent, Basin 2 also has favorable characteristics for harnessing drainages for agriculture. The trunk streams of Basins 2, 4, and 5 reach farther into the flats and across the several zones of energy transfer than do

Table 3.1. Drainage basin morphology

	Basin 1	Basin 2	Basin 3	Basin 4	Basin 5	Basin 6
Basin Area (sq km)	1.66	4.82	2.39	4.88	9.60	9.65
Basin Length (km)	2.90	4.51	3.35	3.96	5.30	4.82
Basin Relief (m)	289.60	290.50	288.00	242.90	199.30	248.40
Basin Perimeter (km)	7.44	10.68	8.52	10.56	15.65	12.84
Basin Circularity	0.25	0.30	0.27	0.40	0.44	0.53
Relief Ratio	0.10	0.06	0.09	0.06	0.04	0.05
Drainage Frequency	26.00	76.00	85.00	75.00	102.00	20.00
Total Stream Length (km)	12.44	30.36	21.15	41.88	23.77	26.94
Mean Stream Length (m)	478.30	399.40	248.90	558.40	233.10	1347.20
Drainage Density	15.65	15.77	35.56	15.38	10.62	2.07
Relative Density	7.49	6.30	8.85	8.59	2.48	2.79
Texture Ratio	3.49	7.12	9.98	7.10	6.52	1.56

those of the other drainage networks. It is at the zones of energy transfer that stream power dissipates and the hydrology is most appropriate for such purposes as prehistoric agriculture.

Basin 1 is steep, has a small catchment area, and contains few streams. Basin 3 is also relatively small and steep, but it has numerous stream segments and some drainages that may have been part of the network prior to the occurrence of stream piracy. Stream piracy is a problem endemic to drainage networks located on alluvial fans, since sediment load is high and stream power is low. The result is a tendency for rapid changes in drainage course, and upper trunks of drainages can be cut off by the establishment of new courses downstream. Two examples of stream piracy that have apparently occurred in the past 30 years can be seen in Basins 3 and 6.

The time perspective offered by differences between the 1955 USGS maps (made from 1954 aerial imagery) and 1984 aerial imagery provides a basis for monitoring changes in drainage channels over a period of 30 years. Although fewer major drainages are indicated on the 1955 maps than were traced from the 1984 imagery, notable changes can be observed for drainages that appear on the earlier maps. Former drainage courses are indicated in Figure 3.2, along with the current drainage pattern. Varying degrees of change in drainages have occurred over the past 30 years, and those differences are probably related to the types of soils being drained. More resistant soils in the Jarilla Mountains tend to show less change in drainage pattern than can be observed for less resistant soils on alluvial fans west of the mountains. Regardless of the degree to which drainage courses have altered, it is evident that the hydrology of the Jarilla Mountains (and particularly of its alluvial fans) is a dynamic system that is continually changing in response to sediment loads and stream power.

These features of alluvial fan drainage systems probably presented formidable difficulties in prehistoric agricultural strategies. Basin 6 is somewhat anomalous in that its large area is filled with a few streams of much greater average length than those in the other drainage basins. This unusual characteristic may again be lithologically controlled, since Basin 6 is part of a radial drainage pattern from a separate set of peaks at the north end of the Jarilla Mountains. Alternatively, the basin area may be in a zone of deposition of windblown sediments scoured out of the basin to the southwest of the mountains, which may have affected the length and number of stream segments.

Climate

The Tularosa Basin lies at the northeastern extent of the Chihuahuan biotic province as described by Dice (1943). The climate of the basin is typical of many of the more arid parts of the southwestern U.S. and northern Mexico. Temperatures are lowest in December and January, and freezing temperatures are common from late November through early March. Daytime temperatures surpass 100 degrees F during the hottest months of the year—June, July, and August (Figure 3.3). The annual frost-free season, which slightly extends the actual growing season, is around 220 days.

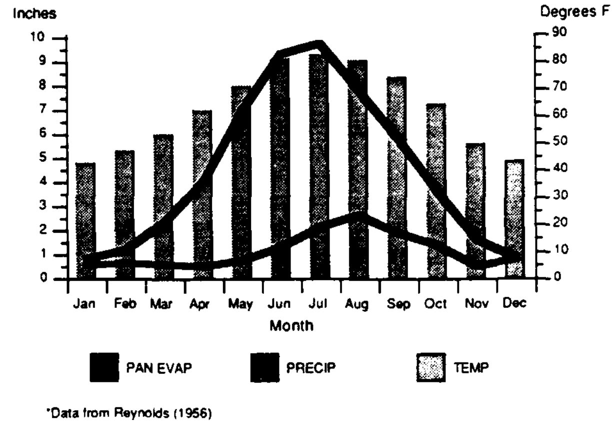


Figure 3.3. Monthly climatic data for Orogrande, New Mexico

Throughout the biotic Chihuahuan Province and much of the arid Southwest the most important factor affecting climate and both plant and animal resources is the availability of water. The Chihuahuan Province is marked by low levels of precipitation, high rates of evaporation, and the near absence of surface water, except as rivers and streams originating in upland areas.

Annual precipitation in the Tularosa Basin averages less than 25 cm (10 in) per year. The rain that does fall on the basin floor is predominantly the product of summer thunderstorms, which form from moisture originating in the Gulf of Mexico. These storms tend to be short, local, and of relatively extreme intensity near their centers, while peripheral areas receive less rain. This pattern of summer-dominant rainfall produces some important effects on the climate of the Tularosa Basin.

Since much of the precipitation in the Tularosa Basin is concentrated into relatively short summer thunderstorms, most of the rain that falls on the alluvial slopes surrounding the basin, or on the hills and mountains within it, quickly runs off and either percolates into sands and unconsolidated gravels or ponds up in playas, where it soon evaporates.

Much of the precipitation in the basin is concentrated into local, intense downpours, and a great deal of the total seasonal moisture of the area is packed into one or a few short-term events. As Figure 3.4 shows, the mean July precipitation measured at Orogrande is skewed by high accumulations, probably the result of thunderstorms passing near or directly over the weather station. Summer months with higher than normal precipitation often have more than twice the mean accumulation. Overall, however, the moisture level for any given month is more likely to be below the mean than above it.

The precipitation figures used here were collected from small, standardized (8 in) rain gauges at weather stations throughout the state (Reynolds 1956). The data are there-

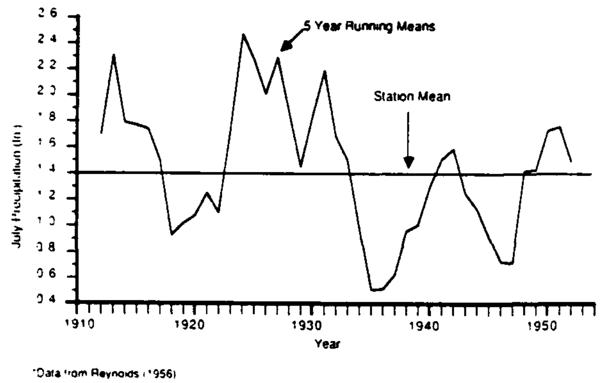


Figure 3.4. July precipitation at Orogrande, New Mexico

fore representative of the precipitation that falls in a relatively small area. In larger areas (such as catchment basins) effective precipitation may be greater than actual precipitation in a small area, since storm centers will be more likely to pass through larger areas and since runoff may concentrate near the bases of alluvial and piedmont slopes.

In the Tularosa Basin annual precipitation varies widely around the mean, and sustained fluctuations can have very dramatic effects. Figure 3.5 shows the summer-dominant rainfall pattern at Orogrande, New Mexico, from 1910 to 1954. The graph shows that summer precipitation always exceeded winter precipitation during this period. An increase in winter precipitation, when evaporation rates are not as high, could have dramatic effects on the environment of the area. These effects could be especially important if the increase in precipitation occurred in the frost-free winter months of April, May, September, and October. Such an increase could significantly expand plant populations, grazing areas, or viable agricultural land.

Although climate and especially drought cycles have been the subject of considerable research, a statistically reliable model for predicting such cycles has not been forthcoming. It is important to note, however, that in the Tularosa Basin, as in the entire state of New Mexico, major climatic fluctuations appear to be regional or even global in scope and that major climatic fluctuations observed outside the basin undoubtedly had major impacts on the climate of the basin itself (Tuan et al. 1973).

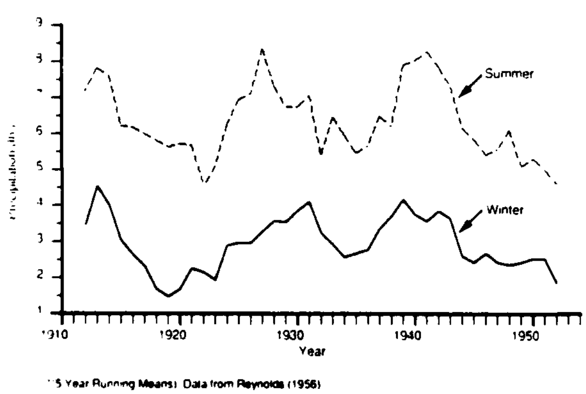


Figure 3.5. Summer vs winter precipitation at Orogrande, New Mexico

Flora

The Border Star survey area can be divided into four broad vegetation communities that roughly correspond to different soil conditions. On the basin floor, mesquite stabilizes the coppice dunes and eclipses most other vegetation. In the area between the dunes, occasional clumps of snakeweed and grasses are found. These species dominate the level, stabilized playa surfaces as well.

Along the alluvial slopes extending off the Jarillas, creosote is the dominant species. The transition from the mesquite community is usually abrupt and corresponds with the dramatic soil change from the fine and medium sands of the basin floor to the the medium and large gravels of the alluvial slopes. The creosote community surrounds the Jarilla Mountains between 1280 m (4200 ft) and 1402 m (4600 ft) except in the prominent gap just north of Monte Carlo Gap, where sands carried by the prevailing southwest-northeast winds have buried the rocky alluvium and mesquite-dominated dunes extend over the entire gap.

Higher in the Jarillas several species of yucca, agave, cactus, and grasses are sporadically found along outcrops and on the upper alluvial slopes. A list of floral species recorded on the Tularosa Basin floor can be found in Eidenbach and Wimberly's report on White Sands National Monument (1980). A review of aboriginal plant utilization is available in the Human Systems Research survey manual (1973b).

Fauna

Despite the relatively harsh environment of the Tularosa Basin, numerous mammalian species are common within the survey area. Mammals observed by the survey crew include jackrabbits (*Lepus californicus*), cottontail rabbits (*Sylvilagus audobonii*), coyotes (*Canis latrans*), kangaroo rats (*Dipodomys merriami* or *Dipodomys ordii*), and bobcats (*Lynx rufus*). A small herd of mule deer (*Odocoileus hemionus*) is known to winter in the Jarilla Mountains. The southern portion of White Sands Missile Range is within the historical range of the jaguar (*Felix onco*) and the Mexican wolf (*Canis lupis baileyi*). A small herd of gemsbok (*Oryx gazella*) was introduced to the range in 1960 and is currently thought to include about 300 animals (Department of the Army 1985a).

Avian species are also quite noticeable in the survey area. Several species of hawk (*Buteo* sp.), unidentified owl (*Otus* sp.), and wild turkey (*Meleagris gallopavo*) were observed as well as quail (*Lophortyx gambelii*) and other smaller birds. Owing to the relatively close proximity of the Rio Grande, additional avian species usually associated with water occasionally visit the southern portion of White Sands Missile Range, but their stay is generally very temporary.

Reptilian fauna are also common in the survey area. Species include diamondback rattlesnakes (*Crotalus* sp.), gopher snakes and coachwhips (Colubridae), transpecos rat snakes (*Elaphe subocucaris*), and various lizards. A more thorough review of the faunal species of the missile range is offered in the Environmental Impact Assessment (Department of the Army 1985a).

Chapter 4

ARCHEOLOGICAL BACKGROUND

Richard C. Chapman

Introductory statements summarizing the archeological background, history of research, or the cultural history for given regions of the Southwest have become increasingly difficult to write in the last few years simply because of the sheer numbers of such background statements that have been generated in response to contract research projects.

These summary statements have striven, on one hand, to provide a detailed chronological framework of prehistoric events as a guide for the casual reader of the report in question, a framework often phrased in terms of the review of previously defined periods or phases of past human behavior. At the same time, these overviews have attempted to critique some elements of methodology and theory underlying the chronological accounting of settlement, site, and cultural variation within a region given the particular researcher's point of interest in the study.

The net result of these concerns has been production of a number of more or less obligatory "background for research" recapitulations of cultural historical reconstructions of Paleoindian, Archaic, Mesilla phase, Doña Ana phase, El Paso phase, and Historic occupation for the Tularosa Basin/Hueco Bolson region.

Several excellent reviews of previous archeological research in the area have been written, and the reader is referred to Carmichael (1983), Marshall (1973), and Wilson (1984), among others for concise summaries of prior investigations.

The objectives of this chapter are instead to review the character of research in the Tularosa Basin/Hueco Bolson as it provides information about the development of method and theory relative to the documentation and understanding of the archeological record for the region. The development and evolution of questions used (implicitly or explicitly) to guide research in the region is also addressed. Emphasis is placed upon the role of archeological survey in that historical process, with equal regard for the kinds of observations made, uses of survey data, and the relationship of survey methods to theoretical development.

It is suggested at the outset that for the Tularosa Basin/Hueco Bolson region, the development of method and the development of theory have been two parallel but not necessarily related processes during the last four decades. For purposes of this discussion, *method* refers to the manner in which observations of the archeological record are made; *theory* refers to the process of positing and evaluating concepts concerning human behavior underlying the formation of the archeological record. The important aspect of these developments, which we are interested in assessing from a historical perspective, is the growth of what might be called *methodology* (referred to by some as middle range theory), that is, the evaluation of the linkages between our observations and our concepts.

Early Research

Much of the early research in the Tularosa Basin/Hueco Bolson region, as summarized in Lehmer (1948), can be characterized as a theoretical concern for identifying "representative" sites of a culture of period. The theoretical underpinnings guiding site selection for investigation were truly cultural and historical, whereby the spatial and temporal distribution of artifacts characterized by a certain constellation of attributes was presumed to reflect the cultural affinity and temporal period of manufacture. Thus fieldwork was oriented toward selection of a site or sites believed to be representative of a temporal period or culture. Work effort focused on the definition of the constellation of ceramic, architectural, and other material attributes that could be used inductively to construct cultural historical sequences for the region.

It can be argued that with the beginnings of salvage archeology in the late 1950's through the 1960's, this fundamental theoretical concern remained largely unchanged. Although the approach to site selection for investigation was dictated opportunistically by pipeline, powerline, and highway construction plans rather than selective need, the basic analytical approach for documentation was to assemble from each site a complete record of the constellation of artifactual and architectural traits, in the hope that the data could be ultimately assembled into a cultural historical sequence of occupation. The period of eclectic and opportunistic data gathering in the immediate vicinity of the Border Star 85 project area is reflected locally by a number of projects that emphasized site excavation, many of which were conducted by the El Paso Archeological Society. These have been well summarized by Marshall (1973) and Carmichael (1985).

Most of this early research clearly focused upon later cultural developments of Formative (ceramic) phases of occupation. Consequently, the Archaic, a major temporal portion of the record of human occupation within the region, was simply not treated in research issues defined during the early period.

Transitional Cultural-Ecological Research

The next phase of research reflected what can be characterized as a paradigmatic change in the theoretical concerns of American archeology. For the Tularosa Basin/Hueco Bolson region, this change first made its published appearance in the Human Systems Research, Inc. *Technical Manual* (1973), which was in essence a design for archeological survey.

The concept of cultural behavior as being more than a sequence of ideational events and attribute systems was introduced in the HSR research design, and this concept was of course reflective of the general tenor of archeological thinking of the time. Human cultural behavior was beginning to be viewed as a *system* that participated in or was interrelated with other elements of larger living systems.

Within this theoretical framework, the *Technical Manual* (HSR 1973) articulated a generalized model of cultural evolutionary process based upon ecological concepts of succession borrowed to a great degree from Margalef (1968). Basic elements of a regional scale seasonal settlement model for the Archaic period were proposed, and particular elements of such models were developed for the Paleoindian and Formative periods, although not in as great detail.

The impact of this shift in theoretical emphasis upon methods was profound. Whereas in the previous period surveys were done strictly within predefined routes or areas (such as highway or powerline rights-of-way) to identify sites that would be impacted by construction, or were undertaken to identify "representative" sites targeted for excavation, the HSR manual reflected much more of a concern for identifying and gathering information about the entire spectrum of material remains comprising the archeological record. The *Technical Manual* (HSR 1973) thus emphasized a survey strategy involving sampling the *landscape* rather that site locations per se as the object of investigation.

Survey levels of observation of the archeological record were treated as a means to gather primary data concerning the interrelationship of cultural behavior and ecological parameters. This conceptual approach constituted in and of itself a radical departure form previous archeological use of survey data. Thus the object of survey was not just to find sites characterized by certain kinds of assemblage attributes as a prelude to "real" data gathering undertaken through excavation. Rather, the objectives of survey explicitly shifted toward the documentation of a wide range of both archeological and environmental data, with the intention of evaluating propositions concerning cultural and ecological interrelationships.

Perhaps the most important aspect of this development was an explicit recognition that observations of the archeological record are *all*, in essence, samples. The HSR survey design dealt with this fact at many different levels of survey observation and across many different categories of information. Thus considerable attention was paid to design of regional sample strategies; methods of survey coverage for archeological materials, soils and vegetation; intrasite sampling strategies, and attribute specific artifact recording. All methods were developed under the guiding premise that a reliable and replicable sample of the archeological record in its entirety must be documented within a region if propositions concerning man-environment relationships and organizational change through time in cultural systems were to be assessed.

Thus by 1973, the rudiments of a region-wide cultural-ecological model of Paleoindian through Formative period behavior in the Tularosa Basin had been proposed, but not evaluated. Perhaps the most significant achievement of the HSR research design resided in the attention paid to *methods* at all stages of the proposed research, and in the fact that the methods proposed for data gathering were explicitly designed to provide information bearing upon the research domains identified as the focus of research to begin with.

The regional research design articulated in the *Technical Manual* (HSR 1973), although never implemented as a single work effort, nevertheless established a broad conceptual framework of settlement and subsistence studies which still serve to guide ongoing research in the Tularosa Basin/Hueco Bolson region.

The Large-Scale Surveys

Beginning in the mid 1970's the effects of Federal and State legislation and regulations governing management of cultural resources began to have a direct effect upon the major federal landowner in the Tularosa Basin/Hueco Bolson region, the U.S. Department of the Army, which began sponsoring large-scale cultural resources inventories of lands under its control. These large scale surveys were carried out in quick succession between 1975 and 1981 at McGregor guided Missile Range, Fort Bliss, and White Sands Missile Range as contracts by the University of Texas at Austin and the El Paso Centennial Museum (Beckes 1977; Beckes et al. 1977, Carmichael 1983, Skelton et al. 1981; Way 1977; Whalen 1977, 1978). Other large-scale and small scale surveys performed during this time under contract to the National Forest Service, the National Park Service and the State of New Mexico included those reported by Eidenbach and Wimberly (1980) Harrill (1980), and Wimberly and Rogers (1977).

In some respects, these survey efforts reflected a continuity of theoretical and methodological approach from that articulated in the *Technical Manual* (HSR 1973). Aceramic manifestations began to be treated as site locations reflecting possible evidence of pre-Formative occupation, and a variety of attempts were made to record isolated features and artifacts as part of the archeological record. A much greater concern with sampling was evidenced in all survey efforts, and many of the projects explicitly recognized the potential effects that different methods of sampling during fieldwork might have upon interpretations made of the data. The conceptual frameworks guiding the surveys were stated as variants of cultural-ecological settlement and subsistence models emphasizing the need to gather data from different landform, soils, and vegetation strata.

At the same time, it can be argued that the advent of federally mandated large-scale surveys in the mid 1970s also marked a point at which the relationship between theoretical concepts and methods of observing the archeological record began to diverge. Managerial needs to inventory and report upon cultural resources over very large tracts of landscape in very short periods of time posed a considerable challenge to a professional archeological community not used to dealing with either large-scale projects or abbreviated reporting schedules. The professional response was that of realism. When faced with the need to perform large-scale inventories which at the same time required only minimal reporting sufficient to render National Register of Historic Places eligibility determinations for discovered archeological sites, development of efficient field methods for data recovery was pursued with vigor.

Significant increases in field efficiency and reporting did (and continue to) result from these mandates, many of which were a function of what could be termed *accessible technology* in the form of aerial photography and photogrammetry. Although detailed aerial photographic coverage capability for the Tularosa Basin/Hueco Bolson landscape had been in existence for several decades, it was not made available to archeologists for routine use in survey until the Department of the Army and other Federal agencies were directed to expedite inventory of cultural resources within their landholdings.

Once released to the archeologists, this technology was quickly refined from its initial use as a mere aid in location of sites to a primary means of survey control and feature and artifact mapping during the sequence of Fort Bliss surveys (Carmichael 1983; Whalen 1977, 1978). By the time the Border Star 85 survey was being planned, the use aerial imagery was conceived as an integral and necessary element of survey method, without which the fieldwork could not have been completed (U.S. Army Corps of Engineers 1984).

In the same sense of increasing efficiency, development of theory by the archeological community was directed (although presumably not consciously) to the formulation of a set of generic settlement-subsistence environmental statements which could be used acceptably in establishing the "role" of any given site in any given phase of past human occupation of the general Tularosa Basin/Hueco Bolson region for purposes of NRHP eligibility determinations.

It can be argued that this process reflected in part the general paradigmatic shift in theoretical orientation for American archeology. At the regional Tularosa Basin/Hueco Bolson level, however, it is perhaps more arguable that the development of what could be termed expedient theory arose as a justification for methods employed.

This development was reflected in the rapid evolution of conventional assumptions that site types reflecting different behavioral components of a synchronic system of behavior could be defined. The site type concept, as expressed explicitly and implicitly in all the major survey reports from the first wave of federally mandated effort in the region, is simply that particular archeological sites are expected to reflect temporally phase-specific manifestations of seasonally specific occupations by an anthropologically understandable social and/or economic group.

From this, survey objectives were to record certain attribute information so that the sites could be taxonomically categorized into predefined component types. The expected analytical result of a major survey project was the definition of a set of site types characterizing (for example) early Mesilla phase or Doña Ana phase settlement, such that one could speculate as to how and why variation among types of sites from one phase to another occurred through time. Variation monitored by these surveys included relative frequencies and locational placement of site types.

It can be argued that this basic approach toward conceptualizing the archeological record is not different in kind from the classic cultural-historical paradigm. The cultural-historical paradigm assumed (from a synchronic perspective) that cultures were composed of individuals who shared similar ideas about the world and that these ideational similarities would be expressed in attributes of their material culture. Analytical methods then took the form of gathering attribute information about artifacts or facilities from difference places in space and drawing ideational isopleth lines around the spatial distribution of those attributes to define cultural boundaries. By arraying these isopleth boundaries along a temporal referent, one could speculate or diagram how ideational systems got larger, smaller, or diffused from one part of the landscape to another.

With respect to the site-type settlement paradigm there quickly evolved conventional assumptions that a settlement system consisted of sites of different types and that one could differentiate those sites according to synchronic, or phase-specific sets, by monitoring certain key attributes of site assemblages. Models of settlement system simplicity, complexity, and change were then developed based primarily upon the number of site types posited to exist in a region.

At a synchronic level of explication, these studies assumed that archeological site locations represented specific episodes of prehistoric occupation, and that through appropriate analysis each site location could yield information about the duration of occupation, season of occupation, size of residential group, and the range of subsistence-related activities performed at the site. Models of phase-specific settlement and subsistence organization essentially posited expectations that seasonal local group relocations within the region would occur in response to perceived environmental factors such as food resource and water availability.

Debate, when it occurred among researchers, focused upon fine-tuning the archeological observations made of site locations with respect to variables of site size, content, or density of archeological remains as they related to extant models of settlement and their predefined subsistence and cultural-evolutionary implications.

The Border Star 85 Survey

The theoretical orientation of the Border Star 85 survey was conceived within a cultural-ecological paradigm, which for the Tularosa Basin/Hueco Bolson region was an outgrowth of a historical process of research development begun in the 1970s.When the Border Star 85 project was designed in 1984, the theoretical outlines of cultural-ecological conventions for understanding settlement behavior within different cultural phases of occupation were well established for the Archaic (Carmichael 1983; Human Systems Research 1972, 1973; O'Laughlin 1980); the Mesilla or Pithouse phase (Beckes et al. 1977; Carmichael 1983; Hard 1983a; Way 1977; Whalen 1977, 1978); and the El Paso phase (Carmichael 1983; Marshall 1973; Mauldin 1984; O'Laughlin 1980; Whalen 1977, 1978). Thus, the suite of research objectives, as originally defined, emphasized the need to establish for each site location the following: better chronological controls, parameters of residential group size, season and duration of occupation, and range of activities performed.

What is of interest in this literature is the absence of any debate concerning (a) the validity of the basic set of assumptions underlying the cultural-ecological conceptualization of human settlement and subsistence behavior and (b) the processes through which the archeological record of that behavior is created. In essence, all these studies implicitly assumed that archeological sites represented the material evidence of interpretable sets of human behavior which, when analytically dissected, could be pieced together to form a synchronic settlement and subsistence system. Differences and similarities among these systems through time could then serve as the subject of analysis directed toward explanations of cultural change. As part of this paradigm, archeological survey methods were largely directed toward locating and documenting site locations, rather than gathering data concerning the actual empirical nature of archeological distributions across the landscape.

The method of data recovery designed for the Border Star survey, however, derived from an entirely different perspective. This method had resulted in part as an independent developmental history related to the legislative need to inventory and manage cultural resources on large tracts of landscape. The concept of a systematic sample approach to the inventory was an outgrowth of several factors, not the least of which was the accessibility of aerial photographic imagery that could be used to establish predefined routes of travel by individual crew members.

Similarly, the use of microcomputers for data entry and preliminary analysis concurrent with fieldwork was made possible by hardware and software technology accessible in 1984, which had not been available for earlier projects. Integration of this computer capability into the project was driven by the need to conduct a fast-track inventory of a large land area for management purposes.

Finally, the strategy of using a systematic sample of the landscape, rather than a priori or post facto judgments in the field as a basis for defining and evaluating archeological site locations, was an outgrowth of a management strategy developed at Fort Bliss to identify and preserve tracts of landscape (rather than individual site locations) containing significant cultural resources. The utility of the method for identifying and evaluating specific site locations was untested at the time the Border Star 85 surveyed was designed.

In summary then, the Border Star 85 project was designed with a set of research objectives which were derived from one line of evolving theoretical development characterizing New World anthropological inquiry. At the same time, the particular survey methods designed for the project can be seen as having evolved almost independently from another line of development related to the changing accessibility of technology and managerial needs to effect rapid inventories of large tracts of landscape. The Border Star 85 project was thus born with an inherent tension between its theoretical underpinnings and its method of data recovery. Much of the analysis in this volume has been directed toward isolating various sources of this tension; it is our hope that one result has been the postulation of the rudimentary outlines of a new approach to the study of the Tularosa Basin/Hueco Bolson archeological record.

Chapter 5

CALIBRATION OF PHASE I DATA: PROBLEMS IN SAMPLING ARCHEOLOGICAL LANDSCAPES

William H. Doleman

Introduction

Instrument calibration consists of the application of an instrument to known quantities for the purpose of discovering the degree and direction of error or bias in the resulting measurements made by the instrument. One major goal of the Border Star 85 Phase II survey effort (June and July, 1986) was to gather data—with a high degree of spatial resolution—from a variety of contexts, for the purpose of assessing the reliability and limitations of the information collected in Phase I. In essence, this constitutes a post-facto calibration of the survey methods.

Measurement represents a crucial aspect of all scientific endeavors, for it is by measurement that scientists can compare their ideas with empirical reality. Only through measurement can scientists reduce the confusing mass of perceptions provided by the world to sets of ordered observations that can be explained or predicted. A concern for accurate instrumentation is a natural consequence of these facts and is evident in the increasing emphasis on quality control in contract specifications for cultural resources work. In most scientific disciplines instrument calibration is commonplace.

In this chapter and the next, the rationale underlying the calibration process, together with the analyses involved, is presented. A significant discrepancy between the target data of the survey (cultural remains) and the measuring instrument used (archeologists and TRU forms) is identified, and the effects of this discrepancy on the survey results are discussed. The calibration has been divided into two chapters in order to ease the burden on the reader and to separate discussions of the *problem* (this chapter) from those of the attempted *solution* (Chapter 6).

This chapter discusses the TRU recording system and, using data from both survey phases, illustrates the nature of the archeological landscape to which it is applied. In addition, Phase I data are used to show that, due to uncontrolled variation in the artifact sampling fractions afforded by the TRU system, the sites identified during the Phase I survey constitute inappropriate units for behavioral analysis. These results are used to warrant the need both for more reliable analytical units and for a calibration analysis to identify the scale of such units. Finally, the process of selecting the Phase II survey units, based on a better understanding of the nature of the cultural landscape, is described.

In Chapter 6, both theoretical expectations of sample reliability and empirical comparisons of Phase I and II data are presented with the ultimate goal of determining the effective resolution of the Phase I data. Through this evaluation, the manner in which these data can best be used to address more traditional settlement and subsistence questions is assessed.

Calibration Rationale

The Phase I TRU data constitute the principal measurements resulting from the Border Star 85 survey and can be fruitfully thought of as a remotely sensed, multispectral image of a portion of the southern Tularosa Basin. In this analogy, the instruments used to create these measurements are the archeologists themselves together with the TRU forms. Given the explicit nonsite approach outlined in the Border Star 85 project solicitation, this remote sensing analogy seems particularly appropriate to the TRU system as instituted by OCA. In the analogy, each class or subclass of data can be said to represent a single wavelength or band measuring one or more different aspects of the cultural landscape; the individual TRUs represent pixels in the image. Response of OCA to the original solicitation from the Corps of Engineers (which mandated a transect survey) envisioned using the TRU data to create distribution maps of culturally significant variables for the survey area. Two related problems, however, led to a need to evaluate the nature of the Phase I data.

First, unlike true remote sensing data, the data from an individual TRU are a *sample* of the area represented by the TRU pixel rather than an *average* (Chapter 2). The Phase I data have two components in this respect: (a) on-transect observations of TRU contents, and (b) off-transect observations. These latter include features (hearths, stains, and fire-cracked rock), estimated lithic and ceramic artifact densities, collectible items (rim sherds and retouched chipped stone tools), and subjective determinations of context (site vs isolated occurrence). The on-transect data constitute a quantitative (6 percent) sample of the Border Star 85 landscape. This quantitative sample is representative only of the TRU itself ($66\frac{2}{3}$ sq m), however, and is not quantitatively representative of the entire $33\frac{1}{3} \times 33\frac{1}{3}$ m block through which the TRU passes (1111 sq m). The off-transect observations, on the other hand, represent a qualitative sample of an observational gray zone extending an unknown distance on either side of the TRU lines. Though qualitative data are particularly useful for defining sites in the laboratory, they can contribute little to quantitative analyses of landscape content.

Second, it is abundantly clear that surface-visible cultural remains are not distributed randomly across the landscape in the Border Star 85 survey area but instead evidence a considerable degree of clustering or aggregation. The result is that most of the cultural remains occur on a relatively small portion of the ground surveyed. Intuitively one can imagine that a system of evenly spaced transects, placed over unevenly spaced clusters of cultural remains, would frequently miss entirely or intercept only the edges of these clusters. Such an observational system would thus provide unreliable samples of cluster content. This is especially true when the size of the target clusters is equal to or is less than that of the transect interval. Furthermore, internal spatial variation in cluster content affects the reliability of transects that do intersect cluster boundaries. McAnany and others (1984) have shown that transect samples carefully placed in the middle of sites do not necessarily provide reliable content estimates for the entire site. Intuition also suggests that the greater the degree of aggregation, the greater the problem.

Much archeological analysis essentially consists of the comparison of assemblages of archeological materials—artifacts, features, and architecture—in quantitative terms (Doleman 1985). Thus, while interpretive paradigms and methods of defining assemblages may vary considerably, the basic assumption that "more things equals more behavior" plays a critical, if implicit, role in most analyses. Consequently, archeologists must attempt to ensure that their data collection methods provide reliable quantitative assessments of assemblage content and that the units of collection can be easily arranged into units of analysis, that is, into assemblages.

Sites have long been the traditional unit used in settlement analysis. The adequacy with which sites were defined and sampled in the field by the Border Star 85 TRU system is questionable, however. For purposes of the Phase I survey, "sites" were defined in the laboratory by grouping adjacent TRUs, which had been identified in the field as belonging to sites using the subjective, experientially based assessment of the individual crew chiefs (see Chapter 2). The preliminary analysis (presented in this chapter) of the Phase I data indicates that most of the sites were inadequately sampled, leading to a need for development of alternative methods of assemblage definition. Considering the nature of the TRU system, the only feasible alternative to the use of sites as units of analysis is the use of the TRUs themselves or of groups of TRUs lumped into blocks or grids. One possibility is that the sampling error in individual TRUs might be cancelled out by such a grouping of observation units.

The TRU system of recording survey data, as implemented on the Border Star 85 Phase I survey, presents an instrumentation problem. There are important questions concerning the effectiveness with which TRUs can sample the clustered remains characteristic of the Border Star 85 survey area and of many other archeological landscapes. The analysis to be reported in this chapter and the next is an attempt to answer some of these questions and to perform a post-facto calibration of the Phase I TRU data as a landscape sampling methodology. At the heart of this analysis lies a comparison of the 100 percent sample data collected in Phase II, from six selected survey units in Area A of the Border Star 85 survey, with the Phase I sample data from the same units. These questions include the following:

1) To what degree do cultural remains cluster in the Border Star 85 area, and how does cluster size vary?
2) How do variations in clustering and cluster dimensions affect TRU sampling reliability?
3) Are there other attributes of the Border Star 85 landscape that affect the representativeness of the TRU data?
4) Can TRUs be grouped to provide more reliable samples of the cultural landscape, and if so, how much lumping is required?
5) How are different variables such as artifact counts, rare versus common artifacts, or artifact variety affected by the degree of clustering and variation in cluster dimensions?

Approaches to Calibration

Two approaches to sample calibration are possible. One, which might be called theoretical calibration, involves taking known population parameters that affect sampling and deriving one or more expected sampling distributions. From these, required minimum sample sizes or optimal sampling designs can be derived. Nance's (1981) discussion of discovery model sampling is an example of this approach (see below). On the other hand, empirical calibration data are sampled using one or more sampling designs and the results compared with the known population (e.g., Judge and Ebert 1975; Plog 1976; Sanders et al. 1979). Although the empirical approach is emphasized here, an attempt is made to outline some theoretical aspects of sampling when the target population is spatially aggregated. The results of both approaches are presented in Chapter 6.

The empirical calibration strategy employed for the Border Star 85 survey data consisted of several steps. First, based on the assumption that the Phase I TRU data reflect at least gross variations in the content and structure of the archeological landscape, the Phase I data were analyzed to define the range of variability extant in the survey in terms of those variables thought to have the greatest effect on TRU sample reliability. Second, several areas that reflect this variability were chosen for intensive survey to collect a 100 percent sample of ground truth data. Third, the results of the resurvey were compared with the Phase I data from the same locations to determine the nature and extent of sampling error inherent in the TRU sample and to discover the relationship between this error and underlying landscape factors, such as density and degree of clustering present. Finally, the effective resolution of the Phase I data was determined, that is, estimates were made of the number of TRUs that must be grouped in order to provide reasonably reliable estimates of landscape content.

As used here, the term *calibration* refers to the process of discovering the limitations of an instrument and not to the derivation of some magical transformation that can be applied to sample data to make them more accurate or useful. In the terminology of sampling theory, this endeavor translates into two related but very different aspects of design effectiveness: accuracy and precision.

In simple terms, an *accurate* sampling design estimates population parameters correctly on the average, while a *precise* one "is highly repeatable" (Cowgill 1975:264) and exhibits little variability in the estimates it yields. Thus, an accurate but imprecise design will provide correct estimates on the average, but individual sample estimates will vary considerably by an unpredictable amount. Conversely, a precise but inaccurate design will tend to yield the same wrong estimate on a regular basis. In essence, the calibration effort represents an attempt to determine the accuracy and precision of the TRU system. The TRU grouping level at which individual errors cancel each other out, resulting in increased precision, is defined as the effective resolution of the system. These concepts are discussed in detail in the beginning of Chapter 6.

The importance of the calibration lies in the fact that the site content data provided by the TRU system are inadequate for site-to-site comparison. Consequently, there is a need for developing alternative units of analysis—in this case, blocks or grids of TRUs. Once the effective resolution of the TRU data has been determined, it should be possible to perform distributional analyses of a variety of cultural or behavioral variables—summed or computed at the appropriate grid size—across the Border Star 85 landscape. Using the remote sensing analogy, such "landscape analysis" (as we have chosen to call it) should produce maps of a given resolution representing images of the cultural landscape that have been filtered for various effects. The resultant images can be compared with various other aspects of the landscape within the framework of particular models of landscape use.

An obvious limitation of this approach lies in the simple fact that the larger the grids used, the less likely it is that the things summed up in them have anything to do with one another. The necessity of using large, arbitrarily shaped and positioned units is a consequence of the TRU system. Nonetheless, it is believed that macro-scale analyses of landscape content may reveal interesting patterns of landscape use that might otherwise go unnoticed in conventional site-based analyses (see below for a discussion of this and other problems).

The results presented in this chapter and the next offer what will be, to some, disconcerting news about the nature of the archeological record in the Tularosa Basin, and significant problems that exist with extant methods for discovering, recording, and interpreting that record. Nonetheless, it is hoped that the following analyses will serve as a guide and a caution to archeologists contemplating the use of transect methods for documenting landscape content and, furthermore, as a stimulus to design new methods for the survey and analysis of low density distributions.

Definition of Sampling Problems

The Nature of the Archeological Landscape

As Mueller has noted, "The field process of discovering prehistoric data conforms precisely to the process of cluster sampling" (1975:39). In cluster sampling, the sample elements (i.e., the individual things from which population estimates are derived) are not sampled directly, but by cluster. In other words, they are included in the sample only if they belong to (usually) randomly selected units or clusters of elements defined by some other factor. Often, such units are spatial e.g., city blocks in a metropolitan survey or, in the case of the Border Star 85 survey, TRUs.

The TRU system used in the Border Star 85 survey consists of a grid matrix of 900 2 by $33^1/_3$ m transect segments per square kilometer of survey area (Chapter 2). The $33^1/_3$ m spacing of the transects walked by the survey crew members means that, theoretically, 6 percent of the surveyed area was subjected to direct observation of quantitative data and that the TRU data from a given area can be conceived of as a systematic cluster sample of that area.

The main drawbacks of cluster sampling are related to the fact that all elements in the underlying sampling universe (the landscape) do not stand an equal chance of inclusion in the sample. Equal selection probability is a prerequisite for element sampling assumed when using most common statistical formulas. One result of the failure to meet this assumption is that cluster samples are less efficient than element samples, where *efficiency* is defined as the standard error of the estimate (the smaller the better). This means that cluster samples almost invariably exhibit larger variances than their element counterparts, which in turn produces a reduction in precision or "effective sample size" (Blalock 1979:567–571). As Nance (1981) has shown, aggregation or clustering of target elements greatly exacerbates the problems associated with cluster sampling and constitutes a major factor to be considered in designing sampling strategies for spatial data.

In order to understand the spatial structure of the Border Star 85 landscape better, various analytical techniques were applied to the Phase I and Phase II data. The results of all analyses indicate that a considerable degree of aggregation is characteristic of most or all the areas surveyed.

Recently, a number of contributions to the surveying literature have criticized the traditional site concept for a variety of reasons (e.g., Camilli 1985; Ebert 1985). Central to these propositions has been a strong implication that much or all of the archeological landscape is a product of formation processes operating over long periods of time. In some cases these processes may appear to be random, but in many they may be quite regular. Concentrations of artifacts and other cultural remains are viewed as the chance results of overlapping distributions representing a variety of prehistoric activities of varying spatial scales and not as the residue of discrete occupational events. The thrust of these recent articles is that archeologists should abandon sites as units of analysis (or at least interpretation) and seek alternatives more in keeping with the formation processes model. Another important consequence of this approach is that off-site phenomena, generally referred to as isolated occurrences, deserve equal analytical attention.

These suggestions constitute a welcome and necessary modification of the traditional approach to the analysis of archeological survey data. However, it is critically impor-

tant that these ideas not lead to the conclusion that random distributions of cultural remains are common. The Border Star 85 data indicate that they are not. Several measures of clustering or aggregation (including ubiquity and variance/mean ratios), support the latter conclusion when applied to data from both phases of the Border Star project.

Theoretically, the grid counts for a distribution of N randomly placed items in a space divided into M equal-sized rectangular grids will approximate a Poisson distribution with a mean grid count (or lambda) of N/M (Hodder and Orton 1976:8). One important characteristic of Poisson distributions is that the variance is always equal to the mean. This fact is useful for assessing the degree to which spatial distributions appear to be random, uniform, or aggregated in structure, and it forms the mathematical basis for Whallon's dimensional analysis of variance (Whallon 1973a).

Whallon's method involves the application of increasing grid sizes to a spatial distribution and monitoring the resulting grid counts and associated variance/mean ratios (V/M), although his computations are actually more complex. Values near 1 indicate randomness; values considerably less than 1 (which are rare) evidence a tendency towards uniformity, and V/M ratios greater than 1 indicate clustering. The preceding makes intuitive sense in that increasing aggregation leads to increased empty space and greater variability in grid counts. Furthermore, aggregated distributions are characterized by a few grids with high counts and many with low or zero counts. This variance/mean ratio method for assessing the amount of aggregation in spatial data requires considerably less computational effort than either the nearest neighbor analysis or the comparison of the actual distribution with a Poisson distribution using a nonparametric test. It also has the added advantage of not requiring point-plotted data (Hodder and Orton 1976:34).

Ubiquity is another useful measure of spatial structure that was developed in the course of analyzing the Border Star 85 data. It is designed to reflect the dispersion of a given number of items in a given space. Ubiquity can be computed in two ways: one corrects for density, the other for absolute measure.

For an area defined by a system of regular-sized grids, the corrected ubiquity of a particular item (U_{cT}) is defined as the number of grids in the system that actually contain the item (X), divided by the number of potentially occupied grids (G) in the whole system, and expressed as a proportion. The number of potentially occupied grids in a system is equal to the number of grids in the system, or the number of artifacts, whichever is less:

$$U_{cT} = X/G$$

Thus, if the total number of items (N) in the area defined by the system equals or exceeds the number of grids (M), then G = M (common with large grid sizes and dense areas). If N is less than M, then G = X (small grids, low density). Under conditions of maximum artifact dispersion U_{cT} should equal 1. As the degree of aggregation increases, more items will tend to occur together in fewer grids. Thus, if a 10 by 10 grid system (100 grids) contains 10 hammerstones that occur in only 5 grids, hammerstone ubiquity is:

$$U_{cT} = 5/10 (= 0.50)$$

An absolute (or uncorrected) ubiquity (U_{aT}), which is equivalent to "relative abundance" (Nance 1981:154), can be calculated by dividing the number of occupied grids by the total number in the system (100 in the above case) and can optionally be expressed as a percentage:

$$U_{aT} = 5/100 \ (= 0.05, \text{ or 5 percent occupancy})$$

This statistic is a somewhat biased measure of dispersion when average (per grid) densities are low or grid sizes are small in relation to the absolute artifact count, since it can never have a value of 1 (100 percent) unless the absolute artifact count equals or exceeds the grid count. Absolute ubiquity, however, is a convenient way of expressing the occurrence rate of various phenomena when the sampling frame is a grid system (Chapter 6). Corrected ubiquity is, perhaps, a fairer measure in that it compares the actual grid space occupied with the maximum possible occupancy (each item in a different grid). Absolute ubiquity simultaneously measures the dispersion and commonness of an item.

Variance/mean ratios and the two ubiquity statistics for the six units surveyed in Phase II, and for Phase I TRU data from a portion of Area A, are presented in Tables 5.1 and 5.2, respectively. In Table 5.1 the Phase II survey units have been ordered by type as defined by the cluster analysis described in the next section of this chapter. Units 1 and 5 are similar, as are Units 2 and 6, in terms of overall density and degree of aggregation, and these four are characteristic of most of the Border Star 85 landscape. Unit 3 is characteristic of areas with large, moderately dense sites, while Unit 4 is a 1 ha portion of a large, dense site (LA 63490). The TRU data presented in Table 5.2 are from an 8 by 8 km area in west-central Area A chosen specifically to avoid areas of unusually high site or artifact density and thus to be representative of the Border Star 85 survey area in general.

The data in Table 5.1 represent a 100 percent sample of the surface and should provide accurate measures of the spatial structure of the surface distribution, although the ceramic statistics for Units 1, 2, and 5 are almost meaningless owing to extremely low densities. The data in Table 5.2 represent the 6 percent TRU sample and are presented for comparison and as estimates of the value of the measure at the larger grid sizes possible with the Phase I data. It should be noted that the counts in Table 5.2 have not been corrected for the sampling fraction (0.06); if they were, the ubiquity figures would not change but the variance/mean ratios would be considerably larger since they are based on squared counts. Feature counts are used in Table 5.2 because fire-cracked rock (FCR) counts were estimated by ordinal scale in the TRU data rather than counted by frequency. Finally, the 500 m statistics for Units 1, 2, 5, and 6 represent a single computation for data from a simulated square kilometer composed of these four units. The four units together should provide characteristic statistics for the Border Star 85 area.

Perhaps the most important aspect of these results is that the variance/mean ratios never equal 1 but continually increase as the grid sizes increase, indicating that surface distributions in the Border Star 85 project areas exhibit aggregation at scales ranging from 2 to 500 m and beyond (depending on the reliability of the TRU data in measuring aggregation).

A chi-square test can be used to measure the significance of the difference between a given variance/mean ratio and a value of 1 (no aggregation) by multiplying the ratio by the number of grids (M) minus one. The result is a chi-square value with M − 1 degrees of freedom, which is also an "index of dispersion" (Hodder and Orton 1976:34). Since M = 62,500 for the 2 m grids, even the smaller variance/mean ratios are significantly larger than 1.

Indices of dispersion (see above) for Phase II lithic, ceramic, and fire-cracked rock counts are presented in Table 5.3. Only grid sizes of 2, 50, 250, and 500 m are included since they are sufficient to show the obvious downward trends. As in Table 5.1, the 500 m statistics are for a simulated square kilometer. Chi-square statistics are not included since all indices are significantly different from 1 and since the associated probabilities are extremely small (e.g., <0.001 for the Unit 1 V/M ratio of 1.8 at 2 m).

Table 5.1. Phase II variance/mean ratios and ubiquity measures by grid size
Unit 1 (Total: 140 lithics, 0 ceramics, 521 pieces of fire-cracked rock)

Grid	Var/Mean Ratios			Corrected Ubiquity			Absolute Ubiquity		
Size	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR
2	1.8	.	8.5	0.77	.	0.25	0.2	0.0	0.2
4	2.3	.	12.5	0.72	.	0.21	0.6	0.0	0.7
6	2.6	.	15.9	0.66	.	0.19	1.3	0.0	1.4
8	3.1	.	16.3	0.63	.	0.18	2.3	0.0	2.4
10	3.3	.	22.5	0.59	.	0.16	3.3	0.0	3.3
14	3.9	.	19.8	0.55	.	0.16	6.0	0.0	6.4
20	4.8	.	28.8	0.49	.	0.14	11.0	0.0	11.5
28	4.7	.	24.1	0.46	.	0.19	20.1	0.0	18.8
36	4.7	.	29.7	0.42	.	0.30	30.6	0.0	30.1
42	5.0	.	31.7	0.39	.	0.36	38.1	0.0	36.0
50	5.3	.	31.2	0.47	.	0.43	47.0	0.0	43.0
56	5.2	.	21.7	0.56	.	0.50	56.4	0.0	50.2
72	7.9	.	38.7	0.71	.	0.66	70.5	0.0	66.4
84	6.5	.	34.2	0.79	.	0.65	79.0	0.0	64.9
100	7.3	.	43.6	0.88	.	0.80	88.0	0.0	80.0
250	17.3	.	120.5	1.00	.	1.00	100.0	0.0	100.0
500	484.5	42.7	90.3	1.00	0.75	1.00	100.0	75.0	100.0

Table 5.1. (continued)
Unit 2 (Total: 1151 lithics, 2 ceramics, 913 pieces of fire-cracked rock)

Grid	Var/Mean Ratios			Corrected Ubiquity			Absolute Ubiquity		
Size	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR
2	7.7	1.0	6.9	0.40	1.00	0.30	0.7	0.0	0.4
4	16.8	1.0	11.1	0.29	1.00	0.23	2.2	0.0	1.3
6	21.0	1.0	18.1	0.25	1.00	0.19	4.1	0.0	2.5
8	28.6	1.0	18.4	0.22	1.00	0.18	6.3	0.1	4.2
10	33.1	1.0	28.3	0.19	1.00	0.15	8.7	0.1	5.6
14	38.8	1.0	27.5	0.16	1.00	0.14	14.7	0.2	9.7
20	69.2	1.0	47.2	0.24	1.00	0.16	23.5	0.3	16.2
28	80.2	1.0	58.3	0.36	1.00	0.25	35.8	0.6	24.8
36	96.7	1.0	84.6	0.50	1.00	0.34	49.8	1.0	34.2
42	89.5	1.0	67.1	0.53	1.00	0.38	52.9	1.4	38.1
50	166.0	1.0	91.7	0.64	1.00	0.47	64.0	2.0	47.0
56	220.5	1.0	115.3	0.65	1.00	0.54	65.2	2.5	53.9
72	178.2	1.0	99.1	0.85	1.00	0.66	85.0	4.1	66.4
84	294.2	1.0	155.6	0.93	1.00	0.68	93.1	5.6	67.7
100	281.6	1.0	171.6	0.96	1.00	0.76	96.0	8.0	76.0
250	856.3	0.7	552.9	1.00	1.00	1.00	100.0	50.0	100.0
500	484.5	42.7	90.3	1.00	0.75	1.00	100.0	75.0	100.0

Table 5.1. (continued)
Unit 3 (Total: 4864 lithics, 4977 ceramics, 5473 pieces of fire-cracked rock)

Grid	Var/Mean Ratios			Corrected Ubiquity			Absolute Ubiquity		
Size	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR
2	15.1	13.2	11.7	0.33	0.26	0.22	2.6	2.1	1.9
4	37.1	32.9	20.5	0.20	0.15	0.13	6.1	4.9	4.4
6	56.4	48.6	32.6	0.14	0.10	0.09	9.9	7.4	7.1
8	70.6	63.4	43.3	0.13	0.10	0.09	12.9	9.7	9.0
10	85.9	88.0	58.3	0.16	0.12	0.11	16.0	12.0	10.9
14	131.6	125.0	85.8	0.22	0.15	0.15	22.3	15.3	15.1
28	257.1	286.4	206.1	0.41	0.26	0.27	40.8	25.7	27.3
36	307.4	383.7	246.3	0.51	0.31	0.36	51.3	31.1	35.8
42	395.4	467.7	311.0	0.57	0.33	0.39	57.2	33.2	38.8
50	539.1	566.5	397,1	0.68	0.37	0.47	68.0	37.0	47.0
56	571.3	714.2	355.4	0.72	0.41	0.51	71.5	41.4	51.4
72	1031.7	1218.2	524.5	0.79	0.48	0.62	78.8	47.7	62.2
84	1099.9	1518.7	815.9	0.90	0.56	0.68	90.3	56.4	67.7
100	920.6	1238.8	690.0	0.96	0.56	0.68	96.0	56.0	68.0
250	2571.8	4789.6	1231.5	1.00	1.00	1.00	100.0	100.0	100.0

Table 5.1. (continued)
Unit 4 (1 ha only) (Total: 1728 lithics, 3730 ceramics, 253 pieces of fire-cracked rock)

Grid	Var/Mean Ratios			Corrected Ubiquity			Absolute Ubiquity		
Size	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR
2	3.5	6.4	4.5	0.42	0.39	0.43	29.3	39.2	4.4
4	7.8	15.8	5.2	0.59	0.69	0.38	58.7	68.6	15.4
6	12.2	25.2	5.6	0.78	0.87	0.33	78.1	87.5	30.2
8	15.8	33.9	5.7	0.90	0.99	0.42	89.6	99.2	41.6
10	20.3	40.7	7.9	0.92	0.98	0.55	92.0	98.0	55.0
14	24.5	57.8	7.4	1.00	1.00	0.82	100.0	100.0	82.3
20	42.8	110.0	9.6	1.00	1.00	0.96	100.0	100.0	96.0
28	80.9	163.9	13.4	1.00	1.00	1.00	100.0	100.0	100.0
36	137.6	330.9	18.0	1.00	1.00	1.00	100.0	100.0	100.0
42	370.9	819.1	29.5	1.00	1.00	1.00	100.0	100.0	100.0
50	272.1	487.0	8.8	1.00	1.00	1.00	100.0	100.0	100.0
56	210.5	241.8	16.4	1.00	1.00	1.00	100.0	100.0	100.0
72	2435.5	6968.8	336.9	1.00	1.00	1.00	100.0	100.0	100.0
84	6570.0	13305.0	879.8	1.00	1.00	1.00	100.0	100.0	100.0
100	.	.	.	1.00	1.00	1.00	100.0	100.0	100.0

The obvious conclusion is that a significant amount of clustering or aggregation is characteristic of the entire Border Star 85 archeological landscape. In no case does the distribution of grid counts resemble the Poisson distribution expected under the null hypothesis of random deposition of cultural remains. Even very large units exhibit large variance/mean ratios, as evidenced in Table 5.2. Overall dispersion as measured by the indices in Table 5.3 does, however, appear to be substantially reduced by increasing grid size. The effect of increasing grid size on apparent dispersion is also evident in the general increase in both ubiquity measures, and it is just this aspect of increased grid size that one hopes will serve to reduce the level of error in pooled TRU samples.

Determination of the grid size for which TRU sampling error is reduced to acceptable levels is the central goal of the calibration analysis. Increasing grid size does not, of course, change the actual structure of the landscape but merely its effective structure (i.e., increased ubiquity) as perceived by a system of arbitrary spatial units. Intuitively, at least, we might expect that increasing the number of TRUs in the sample of an area would improve sample reliability by averaging out the effects of individual TRU hits and misses while increasing overall element sample size.

In seeking clues for determining the level of effective resolution it is tempting to choose as a minimum threshold the grid size at which ubiquity measures approach 1. The rationale behind this idea lies in the nature of the original problem: aggregation. Grid systems applied to spatially clustered data yield highly variable results. However, if the grid size is increased (by grouping the original sample

Table 5.1. (continued)
Unit 5 (Total: 172 lithics, 9 ceramics, 558 pieces of fire-cracked rock)

Grid Size	Var/Mean Ratios			Corrected Ubiquity			Absolute Ubiquity		
	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR
2	3.7	1.7	11.9	0.65	0.78	0.26	0.2	0.0	0.2
4	4.2	1.7	12.9	0.57	0.78	0.23	0.6	0.0	0.8
6	5.4	1.7	14.6	0.54	0.78	0.20	1.3	0.1	1.6
8	6.4	1.9	15.5	0.47	0.67	0.19	2.1	0.2	2.7
10	6.8	1.9	20.8	0.46	0.67	0.17	3.2	0.2	3.8
14	7.4	1.9	25.3	0.44	0.67	0.15	5.9	0.5	6.7
20	8.1	1.9	24.1	0.40	0.67	0.13	10.9	1.0	11.5
28	10.2	1.9	32.8	0.34	0.67	0.21	18.2	1.9	20.7
36	13.2	3.4	30.8	0.30	0.44	0.31	27.0	2.1	31.1
42	11.7	2.1	35.4	0.34	0.56	0.36	33.9	3.5	36.0
50	12.2	2.0	45.5	0.42	0.56	0.47	42.0	5.0	47.0
56	12.4	2.0	42.9	0.48	0.56	0.59	47.7	6.3	59.0
72	15.5	3.3	32.8	0.64	0.44	0.71	64.3	8.3	70.5
84	15.9	3.3	53.8	0.73	0.44	0.76	73.4	11.3	76.2
100	18.6	3.2	49.0	0.80	0.44	0.88	80.0	16.0	88.0
250	27.6	6.6	129.8	1.00	0.50	1.00	100.0	50.0	100.0
500	494.5	42.7	90.3	1.00	0.75	1.00	100.0	75.0	100.0

Table 5.1. (continued)
Unit 6 (Total: 379 lithics, 57 ceramics, 367 pieces of fire-cracked rock)

Grid Size	Var/Mean Ratios			Corrected Ubiquity			Absolute Ubiquity		
	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR	Lithics	Ceramics	FCR
2	5.4	3.5	6.6	0.38	0.47	0.32	0.2	0.0	0.2
4	13.6	3.6	10.2	0.28	0.44	0.23	0.7	0.2	0.5
6	24.2	4.4	13.2	0.23	0.40	0.20	1.3	0.3	1.1
8	29.6	3.8	17.8	0.22	0.39	0.17	2.1	0.6	1.6
10	51.4	6.1	28.7	0.21	0.35	0.16	3.1	0.8	2.3
14	46.8	4.6	22.7	0.17	0.35	0.14	5.2	1.6	4.0
20	70.7	8.4	45.2	0.16	0.30	0.12	9.9	2.7	6.9
28	63.2	8.5	43.4	0.16	0.26	0.11	15.7	4.7	11.3
36	71.2	7.8	40.9	0.25	0.26	0.17	24.9	7.8	16.6
42	78.7	9.3	62.2	0.29	0.23	0.19	28.9	9.2	19.1
50	174.5	19.6	108.3	0.38	0.21	0.29	38.0	12.0	29.0
56	179.3	19.6	108.3	0.41	0.19	0.31	41.4	13.8	31.4
72	133.3	12.2	69.1	0.58	0.23	0.39	58.1	22.8	39.4
84	97.9	15.4	83.7	0.62	0.25	0.45	62.1	25.4	45.2
100	193.6	30.7	146.9	0.72	0.32	0.64	72.0	32.0	64.0
250	232.2	26.7	149.2	1.00	0.75	1.00	100.0	75.0	100.0
500	484.5	42.7	90.3	1.00	0.75	1.00	100.0	75.0	100.0

units into larger grids) to a threshold at which the distribution no longer appears aggregated, then the effects of aggregation should be reduced. Unfortunately, as pointed out earlier, this approach sacrifices spatial resolution for sample reliability. The result is a low resolution, average but reliable sample of landscape content.

Using the Phase II data from the four typical Border Star 85 units (Table 5.1, Units 1, 2, 5, and 6), this threshold appears to be at about 250 m for lithics and fire-cracked rock but greater than 500 m for ceramics. In Unit 3 (a high density landscape) the U = 1 threshold for all three classes is 250 m, while in Unit 4 (one of the densest portions of the survey area) the threshold is considerably lower: ca. 14–20 m.

The Phase I data suggest higher thresholds overall. For lithics and features, ubiquities equal 1 at the 667 m level (20 by 20 TRU blocks); for ceramics the level is again higher at 1000 + m. In general, these data suggest an overall ubiquity threshold of 500–1000 m, that is, a level at which one might start looking for effective resolution. If however, the ubiquity figures for the Phase II data are representative of the survey area as a whole, then the actual distribution being sampled is ubiquitous (at least for lithics and fire-cracked rock) at a scale of 250–500 m.

Table 5.2. **Phase I variance/mean ratios and ubiquity measures by grid size West-central portion of Area A (Total: 5544 lithics, 2850 ceramics, 4760 features)**

Grid	Var/Mean Ratios			Corrected Ubiquity			Absolute Ubiquity		
Size	Lithics	Ceramics	Feats	Lithics	Ceramics	Feats	Lithics	Ceramics	Feats
100	12.93	107.87	4.94	0.33	0.11	0.33	28.94	4.97	24.56
200	16.20	145.28	7.93	0.65	0.16	0.57	65.13	16.13	57.13
267	18.60	176.55	10.01	0.81	0.26	0.73	81.44	26.11	72.67
333	21.19	167.00	12.21	0.90	0.34	0.85	90.10	34.37	84.55
400	21.08	179.40	11.80	0.99	0.47	0.92	98.75	47.25	92.00
500	23.40	138.00	15.89	0.98	0.59	0.97	98.44	58.59	96.88
667	32.35	173.58	21.99	1.00	0.80	1.00	100.00	79.86	100.00
800	35.88	188.16	23.65	1.00	0.89	1.00	100.00	89.00	100.00
1000	39.89	198.76	27.26	1.00	0.94	1.00	100.00	93.75	100.00
1333	72.49	232.57	54.04	1.00	1.00	1.00	100.00	100.00	100.00
1600	124.63	269.45	105.97	1.00	1.00	1.00	100.00	100.00	100.00
2000	114.50	219.62	112.95	1.00	1.00	1.00	100.00	100.00	100.00
2667	440.64	518.49	369.22	1.00	1.00	1.00	100.00	100.00	100.00
4000	717.84	439.75	707.69	1.00	1.00	1.00	100.00	100.00	100.00

Several aspects of these figures are particularly informative when the nature of the Border Star 85 landscape and the way in which it was sampled by the TRU system are examined. First, ubiquity values based on TRU data are uniformly lower than those for equivalent grid sizes in Phase II data. These lower levels reflect the underestimation inherent in the TRU data and demonstrate that the TRU system misses considerable quantities of cultural remains. The result is an inaccuracy in sampling, which is discussed in detail in Chapter 6. In this light, it is interesting to note that the Phase I lithic ubiquity values only approximate the true Phase II values at the 300–500 m level. For example, while the Phase II absolute ubiquities for the four typical units range from 72 to 96 percent at the 100 m level, the corresponding figure for the TRU data is 28 percent, or one-third the average real value. Perhaps coincidentally, the estimated overall inaccuracy of the TRU data (see below) is 67 percent, or a factor of three.

Second, with the exception of Unit 4 (a large, dense site), ceramics are generally less ubiquitous than lithics or fire-cracked rock. This observation is particularly obvious in the absolute ubiquity figures for Phase II Units 3 and 6 and the TRU data. Lower ubiquity indicates greater aggregation and, presumably, increased sampling error in the TRU data for ceramics. The difference in ubiquity between ceramics and the other two artifact classes reflects the fact that ceramics were more commonly documented at sites (de facto aggregations) than at isolated occurrences.

Table 5.4 shows the Phase I distribution of lithics, ceramics, and features (largely fire-cracked rock scatters and ash stains) with respect to the context in which they were discovered (sites and isolated occurrences as defined in the field; see Chapter 2). As noted above, sites are de facto aggregations and comprise a convenient means for comparing the artifact and feature content of the aggregated and dispersed portions of the actual distribution. From the data presented in Table 5.4, it can be seen that features fall between lithics and ceramics in the degree to which

Table 5.3. Lithic, ceramic, and fire-cracked rock dispersion indices by grid size for Phase II units

<table>
<tr><th>Material</th><th>Grid</th><th colspan="6">Units*</th></tr>
<tr><th>Type</th><th>Size</th><th>1</th><th>5</th><th>2</th><th>6</th><th>3</th><th>4</th></tr>
<tr><td>Lithics</td><td>2</td><td>112360</td><td>229479</td><td>483048</td><td>337187</td><td>945151</td><td>8718</td></tr>
<tr><td></td><td>50</td><td>526</td><td>1209</td><td>16438</td><td>17273</td><td>53371</td><td>816</td></tr>
<tr><td></td><td>250</td><td>52</td><td>83</td><td>2569</td><td>697</td><td>7715</td><td>—</td></tr>
<tr><td></td><td>500</td><td colspan="4">1454</td><td>0</td><td>—</td></tr>
<tr><td>Ceramics</td><td>2</td><td>—</td><td>104158</td><td>62498</td><td>215952</td><td>824777</td><td>16039</td></tr>
<tr><td></td><td>50</td><td>—</td><td>202</td><td>98</td><td>1938</td><td>56088</td><td>1461</td></tr>
<tr><td></td><td>250</td><td>—</td><td>20</td><td>2</td><td>80</td><td>14369</td><td>—</td></tr>
<tr><td></td><td>500</td><td colspan="4">128</td><td>—</td><td>—</td></tr>
<tr><td>FCR</td><td>2</td><td>530789</td><td>741377</td><td>433575</td><td>410907</td><td>730332</td><td>11298</td></tr>
<tr><td></td><td>50</td><td>3093</td><td>4506</td><td>9083</td><td>10721</td><td>39316</td><td>26</td></tr>
<tr><td></td><td>250</td><td>362</td><td>389</td><td>1659</td><td>447</td><td>3694</td><td>—</td></tr>
<tr><td></td><td>500</td><td colspan="4">271</td><td>—</td><td>—</td></tr>
</table>

***See text for discussion of unit groupings based on cluster type.**

Table 5.4. Cultural remains from Phase I sites and isolates

Class	Source: Sites	Source: Isolates	Total
Lithics	11,429	6,804	18,233
Row %	62.7	37.3	
Column %	15.1	23.7	
Ceramics	57,813	19,271	77,084
Row %	75.0	25.0	
Column %	76.4	67.1	
Features	6,473	2,639	9,112
Row %	71.0	29.0	
Column %	8.6	9.2	

they occur on sites: 71 percent of features occur on sites vs 75 percent of ceramics and 63 percent for lithics.

The fact that lithics and fire-cracked rock (or features) are more ubiquitous than ceramics (which tend to cluster on sites) has implications both for the nature of landscape use in the Border Star 85 area and for the significance of isolated occurrences as separate behavioral phenomena. Isolated occurrences are often regarded—either explicitly or otherwise—as unimportant aspects of regional archeological distributions. The results presented below in the section on empirical calibration and in Chapter 6 suggest otherwise.

Third, and not surprisingly, sites—as represented in Unit 4—have more occupied space than other portions of the landscape, as illustrated by the absolute ubiquity figures for Unit 4 when compared with those from the other units. Furthermore, using Units 3 and 4 as analogues for large, dense site areas, it appears that such areas are internally less aggregated than the landscape as a whole. Athough in general, higher average densities yield higher variance/mean ratios, their ratios for Units 3 and 4 are roughly equal to or only slightly higher than those for other units. Units 3 and 4 exhibit much higher densities than the other Phase II units. This appears to be particularly true for scales of resolution of less than ca. 25 m. Thus, large sites, which have more dense concentrations of artifacts and features than nonsite areas, are subject to less sampling error than the landscape in general. This sampling error pattern does not obtain for the small sites, which are far more abundant in the Border Star 85 project area.

It should be clear from the above discussion, that the Phase I TRU data are potentially subject to considerable sampling error. Aggregation in the cultural landscape exists at multiple scales from 2 to 4000 m. While sites appear somewhat less internally aggregated than cultural remains when considered by class, the fact that sites have increased densities of remains generally exacerbates the aggregation problem. Furthermore, the degree of aggregation varies from one artifact class and one area to another. The data also suggest that the TRU system severely underestimates landscape content overall and that, possibly, some sort of ubiquity threshold may exist at grid sizes of 500–1000 m.

The implications of significant aggregation in the distribution of artifacts and features across the landscape, for the reliability of the Phase I data, are considerable since aggregation is expected to increase the sampling error already associated with cluster sampling designs, such as the TRU system. In essence, the Phase I data from a single square kilometer represent a sample of the landscape consisting of 900 66.7 sq m cluster sample units. When the absolute ubiquity figures from Table 5.1 are used as measures of occupied space, we can define unoccupied space as

$$U_{oT} = 100 - U_{aT}$$

where U is unoccupied space and U_{aT} is absolute ubiquity.

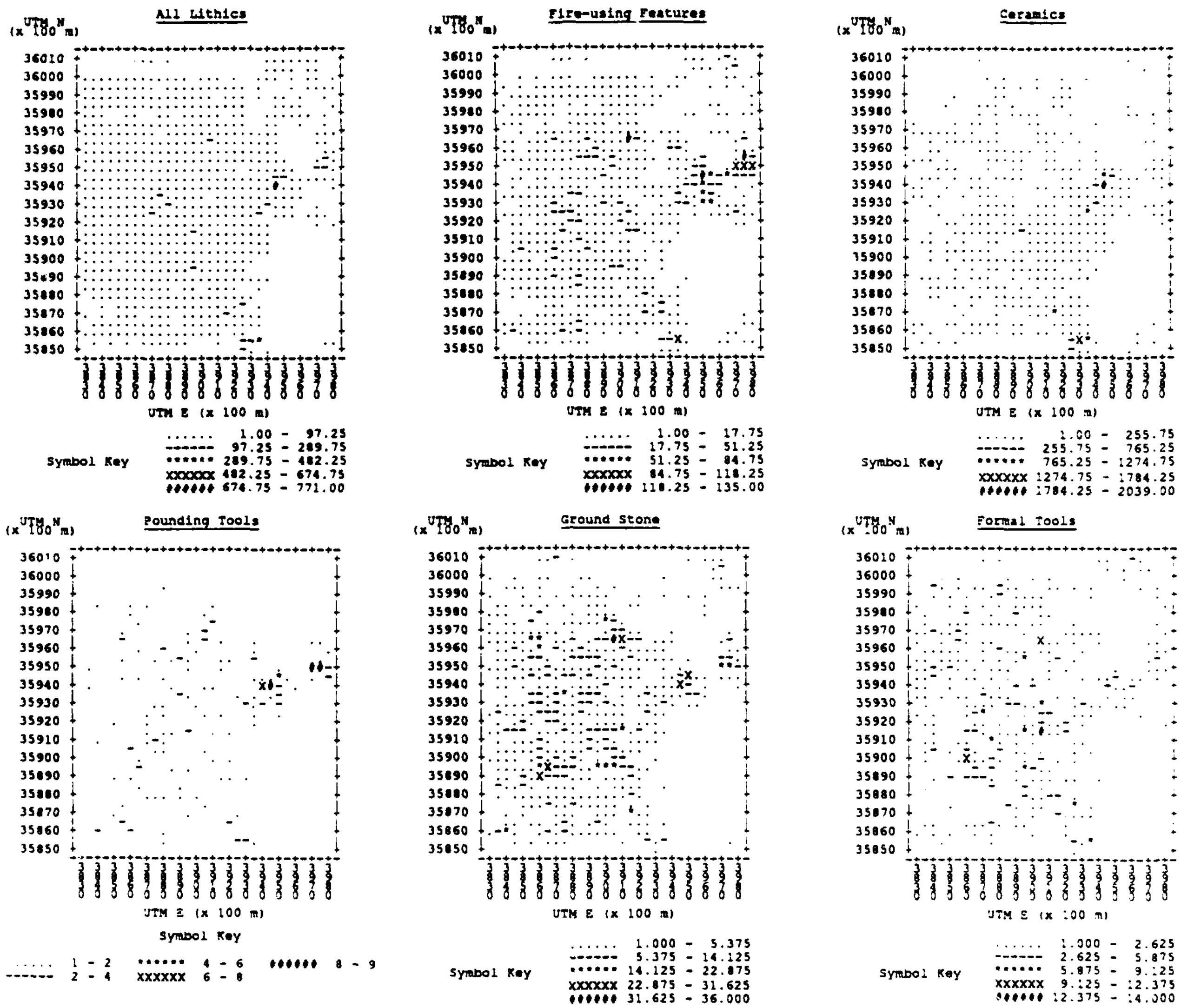
If each TRU is conceived of as equivalent to an 8 by 8 m square (the closest square approximating the 66.7 sq m area of a single TRU), then the TRU data constitute a 6 percent sample of space, which in terms of the most ubiquitous items, lithics, is between 87 and 98 percent empty (excluding Unit 4). In other words we might ask: "Just how useful is a 6 percent sample of almost nothing?" Poor sampling of space leads to poor sampling of its content.

Table 5.5 shows the percentage of empty grids at an 8 m scale of resolution for lithics, ceramics, and fire-cracked rock for all six Phase II units. As noted above, empty grid percentages are a measure of unoccupied space. The data from Unit 4 reflect on-site artifact densities in an extreme case and, therefore, are not surprising. The rest of the figures, however, clearly indicate that much of the cultural landscape is empty, a fact that again illustrates the degree of aggregation present and the magnitude of its potential effects. The scale (8 by 8 m) selected for the analysis certainly affects the resulting figures, but smaller grid sizes, which might be conceived of as more honest, lead to even smaller amounts of occupied (or larger amounts of unoccupied) space.

The spatial distributions that characterize the Border Star 85 cultural landscape can be illustrated in many ways. Figure 5.1 depicts plots of Phase I TRU data at 500 m grid densities in Area A for six artifact classes of varying abundance: lithics, ceramics, features evidencing the use of fire, ground stone, pounding tools (i.e., hammerstones, mauls, and anvils), and formal lithic tools. It can be seen that the various artifact classes vary in both ubiquity and overall density. Density variations at the 500 m scale reflect the effects of aggregation on grid counts. Aggregation is apparent in the relatively low frequency of high-density grids (boldface characters) compared with the more common low-density ones (dots and plus signs). Although slightly more abundant overall, ceramics are clearly more aggregated

Table 5.5. Phase II units: Percentage of unoccupied grids

Data Class	Units: 1	5	2	6	3	4
Lithics	97.7	97.9	93.7	97.9	87.1	10.4
Ceramics	—	—	—	99.4	90.3	0.8
FCR	97.6	97.3	95.8	98.4	91.0	58.4



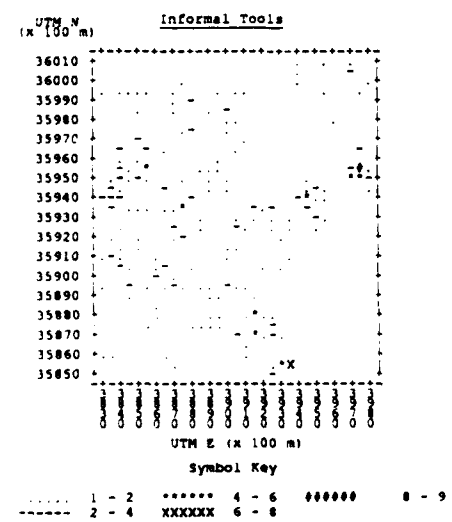


Figure 5.1. 500 meter plots of Area A—Phase I

than lithics. Fire-cracked rock/ash features and especially ground stone appear to be more ubiquitous than might be expected given their presumed association with residential locations. Interestingly, formal tools are fairly ubiquitous, and their distribution does not appear to be correlated with those of the more common ceramics and lithics.

Aggregation is even more evident in Figures 5.2–5.7, which are contour maps of the 10 m grid densities for three Phase II artifact classes: lithics, ceramics, and fire-cracked rock. The figures are presented in order by the landscape types defined above (unit groupings: 1/5, 2/6, 3, and 4). In Units 1 and 5, which represent a low-density, somewhat dispersed landscape type, aggregation is manifested as many small groups of artifacts. In Units 2 and 6, aggregation appears as both small and large concentrations, and in Unit 3 large concentrations predominate. Unit 4 (the high-density site) appears as a continuous distribution that varies considerably in density.

In addition to exhibiting the variations in landscape structure present in the Border Star 85 survey area, Figures 5.2–5.7 also show the degree to which the distributions of different artifact classes are isomorphic. For example, in Unit 1 (which lacks ceramics) the distributions of lithics and fire-cracked rock appear similar, as they tend to be for most of the units. On the other hand, Units 3 and 6 clearly show the clustering tendencies of ceramics, and in Unit 4 ceramics appear most ubiquitous and fire-cracked rock most aggregated.

As final illustrations of spatial distributions, 2 m grid maps of the Unit 4 area are shown in Figure 5.8 and indicate the aggregation present at on-site, high-density, high-resolution scales. Most of the holes in the distributions are coppice dunes, which are undoubtedly underlain by artifacts and do not represent truly empty space. Nonetheless, it can be seen that artifact densities vary considerably and that, although the three distributions appear largely isomorphic, the correlations are not exact.

It is important to consider the vast differences in scale represented in Figures 5.1–5.8. In Figure 5.1, each character or print position represents a 500 m grid. In Figures 5.2–5.7 each character represents a 10 m grid, and in Figure 5.8 each position represents a 2 m grid. Aggregation is apparent at each scale. Thus, potential grid-sampling problems can be expected at many different scales.

Sampling Landscapes and Sites for Assemblage Content

Figures 5.9–5.14 are side-by-side contour plots of Phase I and Phase II artifact densities for the Phase II survey units. The scale of resolution is the TRU (each character represents one TRU or an area $33^{1}/_{3}$ m on a side). Lithic, ceramic, and feature densities (counts) from the Phase I data appear on the left; lithic, ceramic, and fire-cracked rock densities from Phase II appear on the right. These figures graphically depict the differences between the Phase I estimates of landscape content and the surface reality as revealed in the Phase II data.

While it is evident that there is a general correspondence

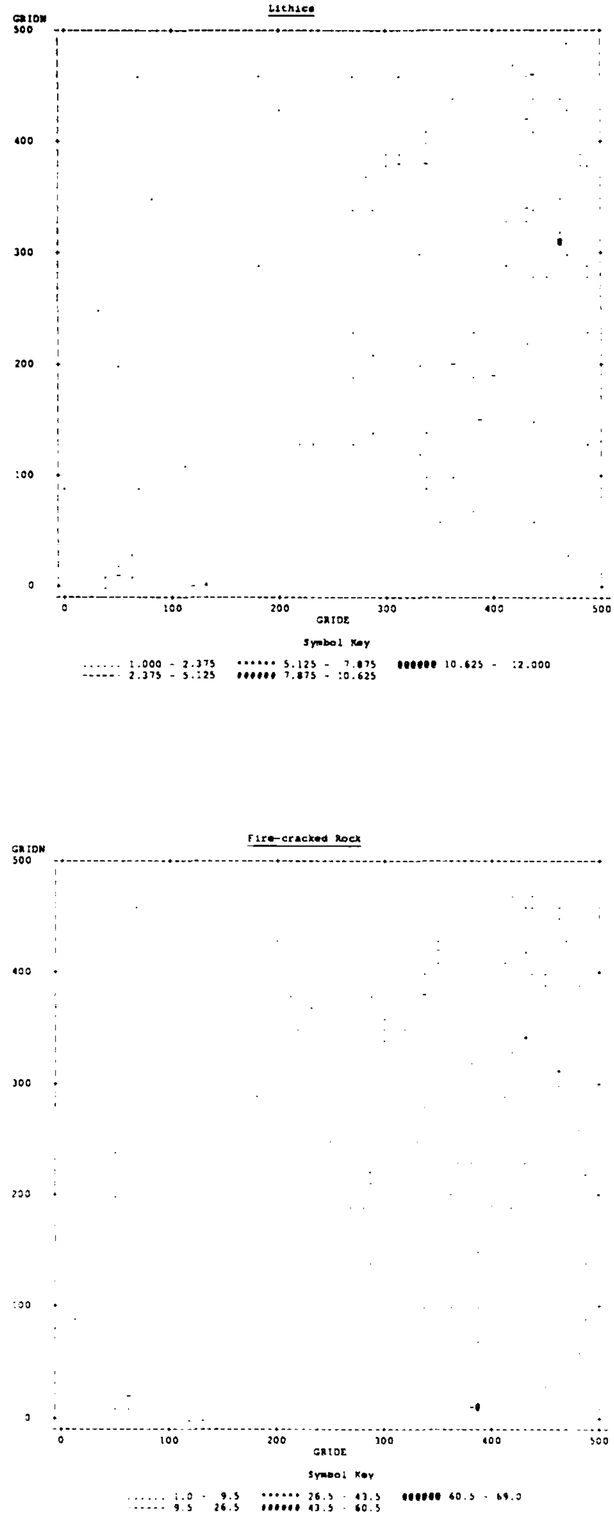
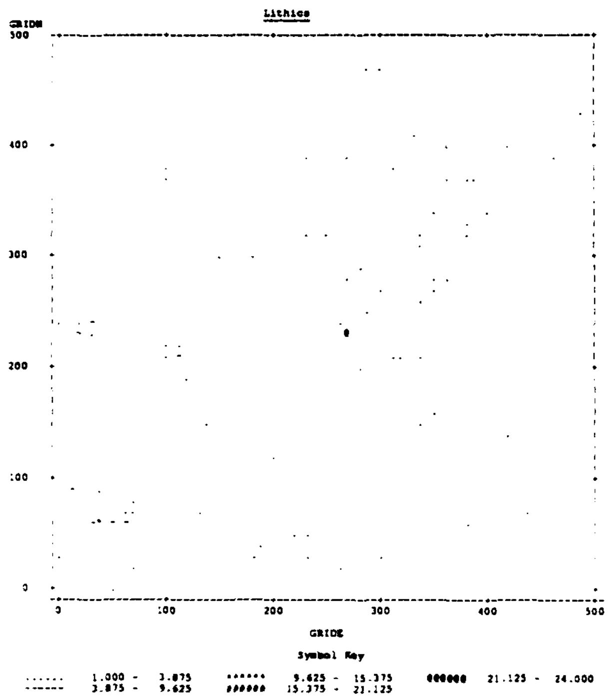
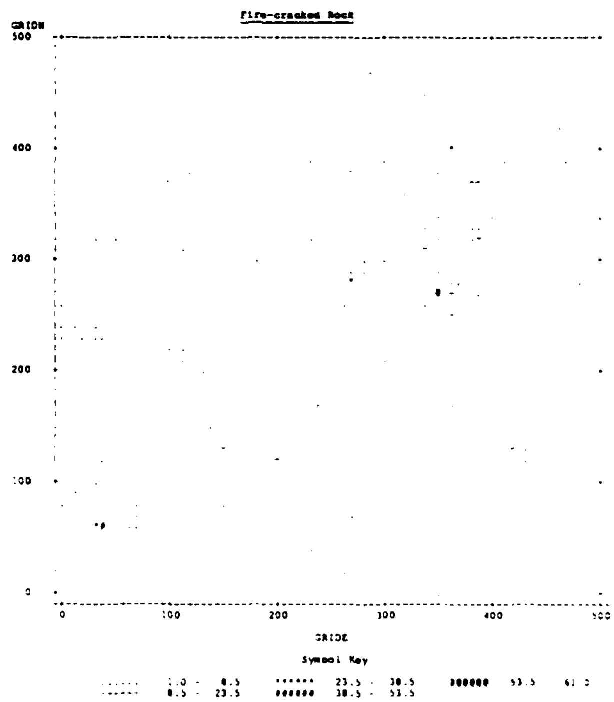


Figure 5.2. 10 × 10 meter plots of Unit 1—Phase II





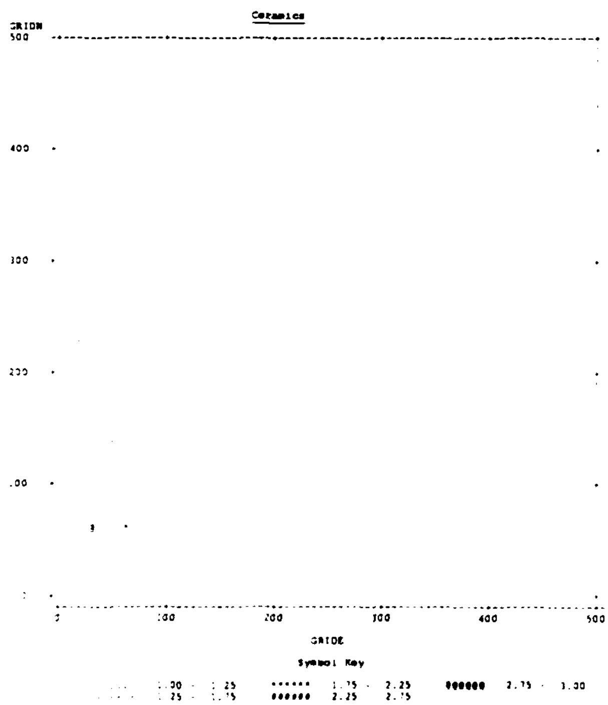


Figure 5.3. 10 × 10 meter plots of Unit 5—Phase II

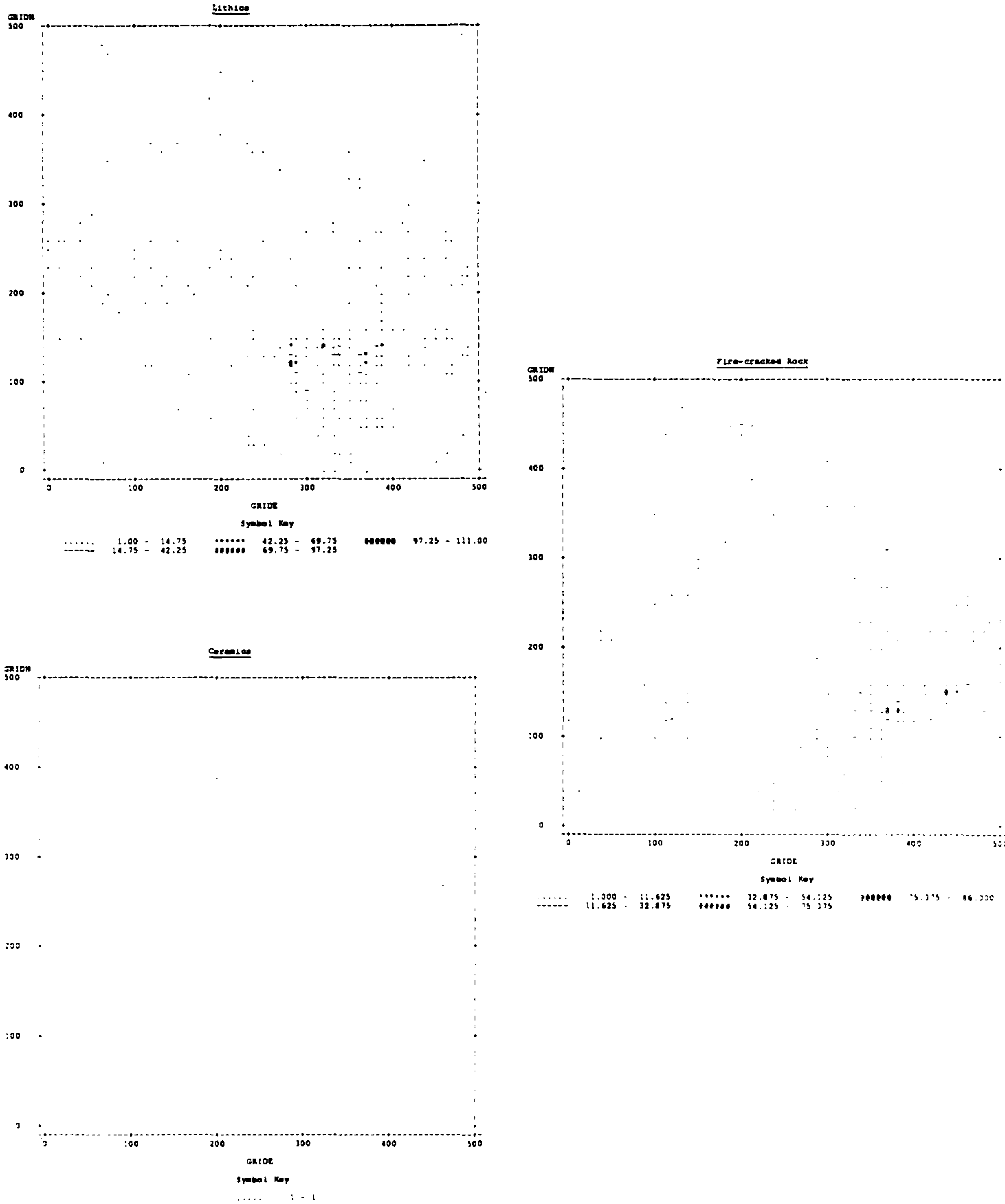
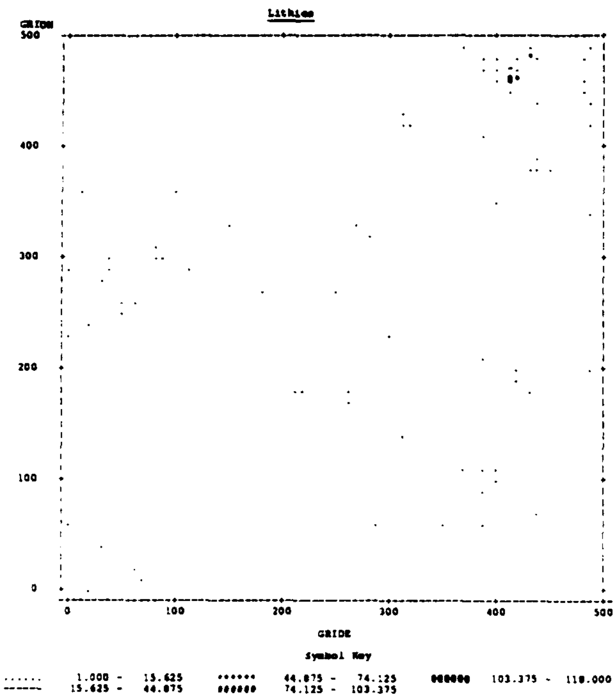
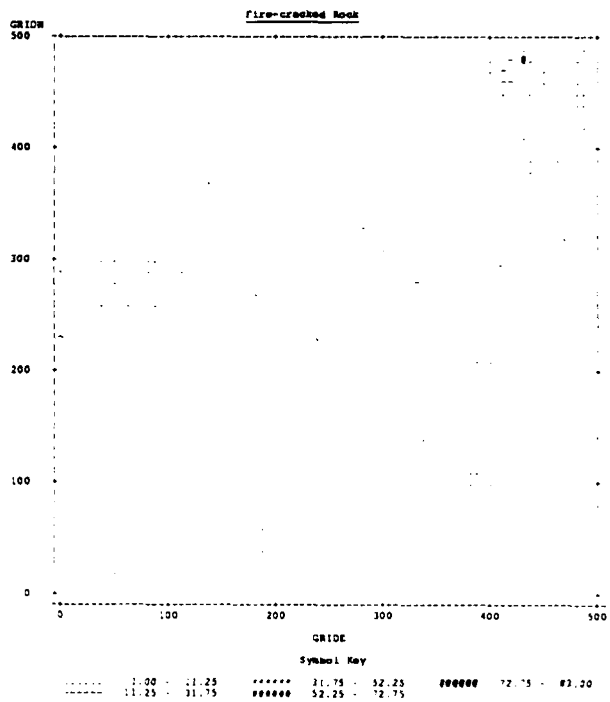


Figure 5.4. 10 × 10 meter plots of Unit 2—Phase II





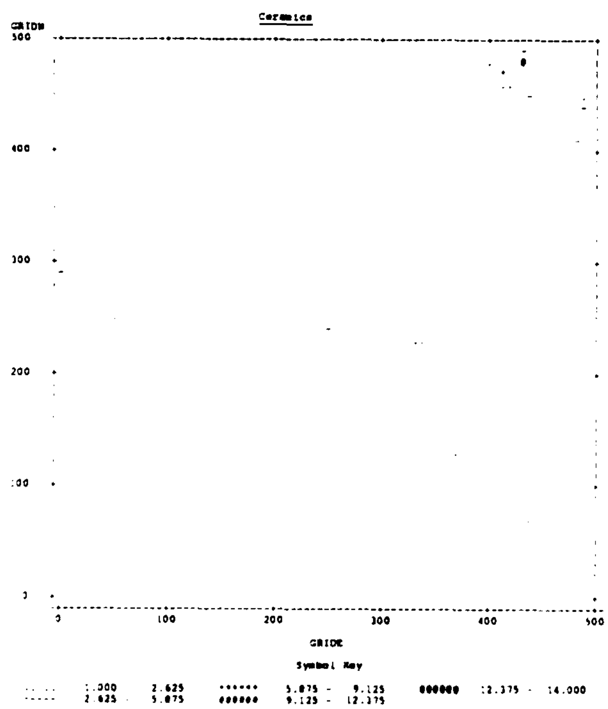


Figure 5.5. 10 × 10 meter plots of Unit 6—Phase II

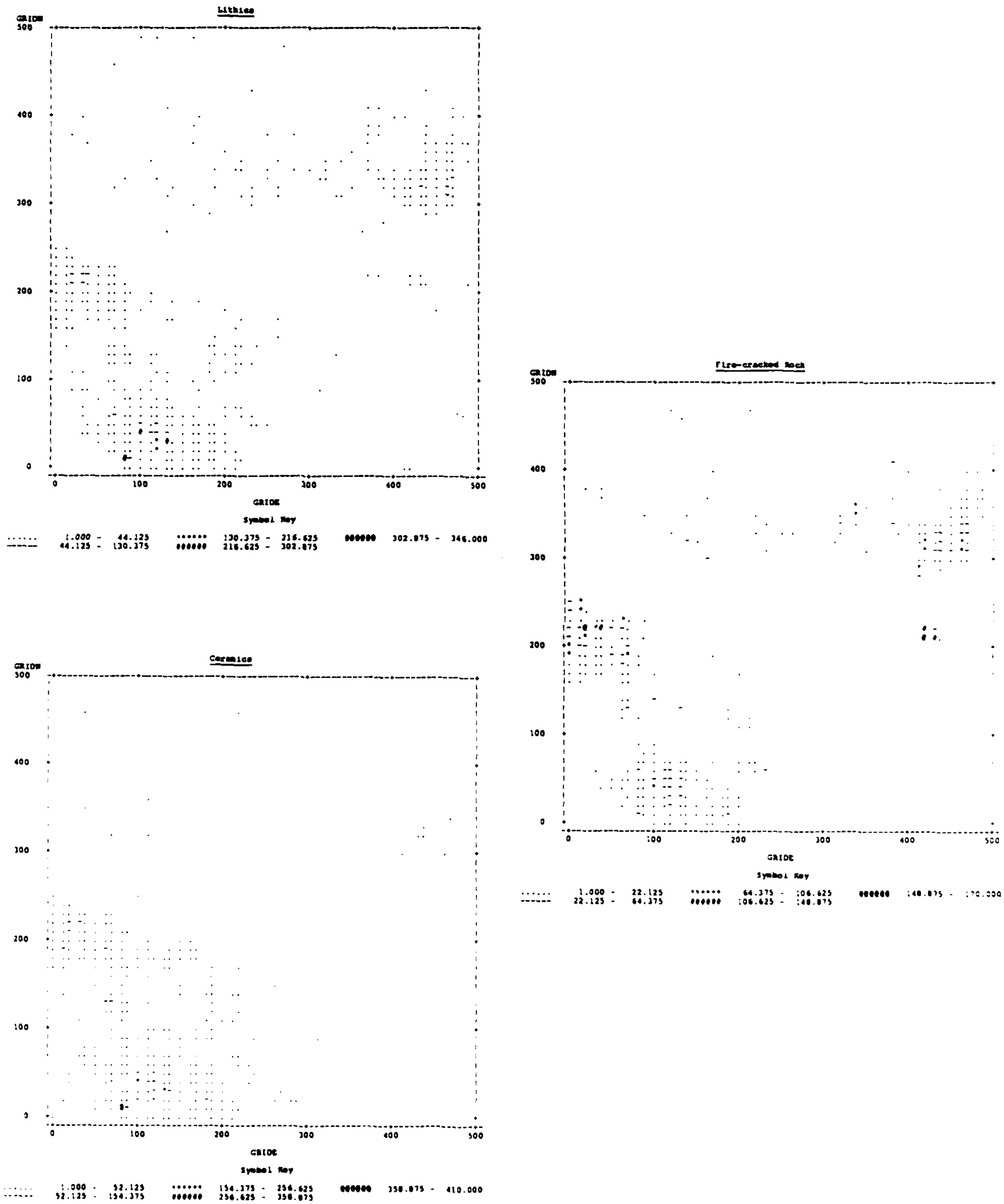


Figure 5.6. 10 × 10 meter plots of Unit 3—Phase II

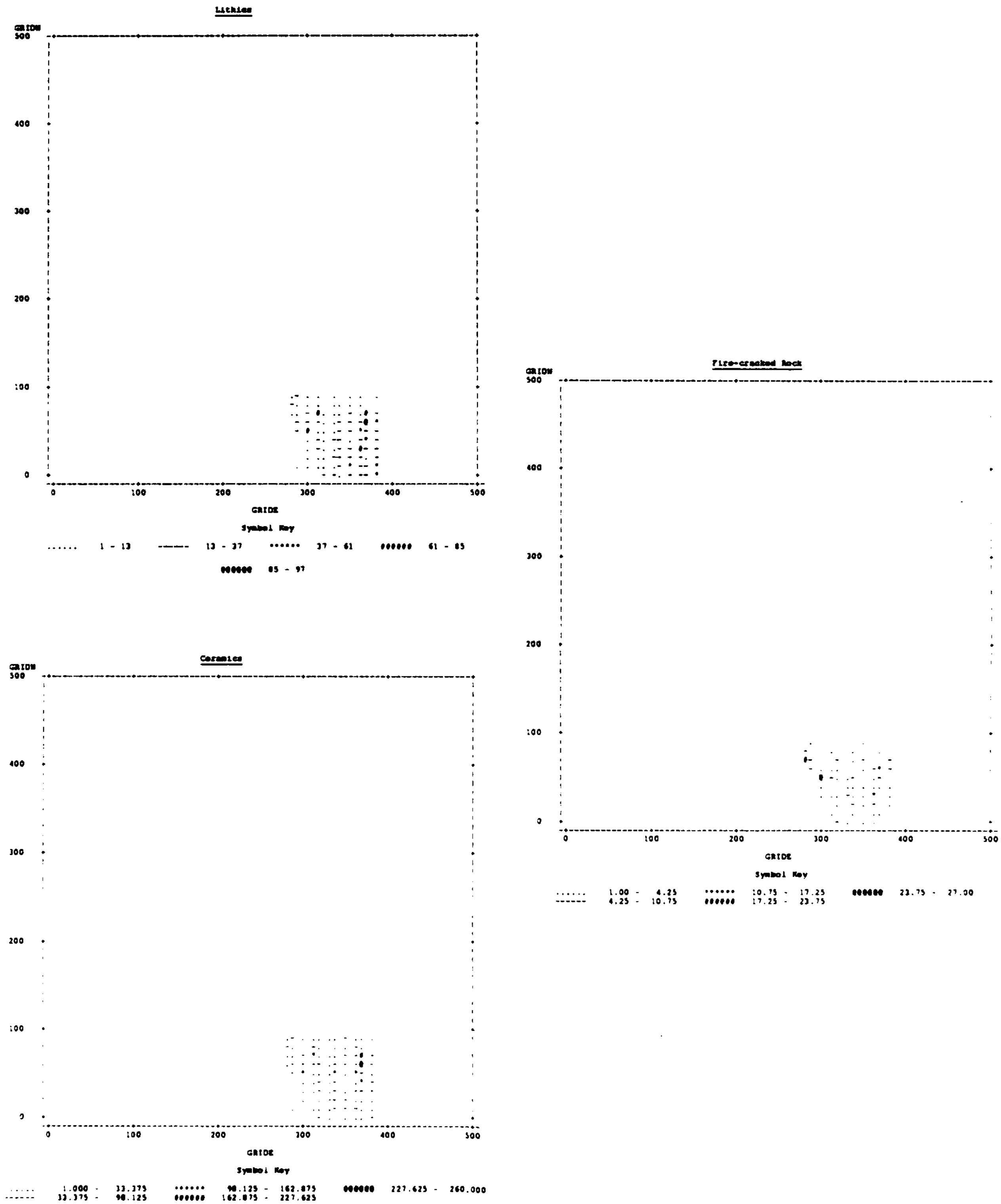


Figure 5.7. 10 × 10 meter plots of Unit 4—Phase II

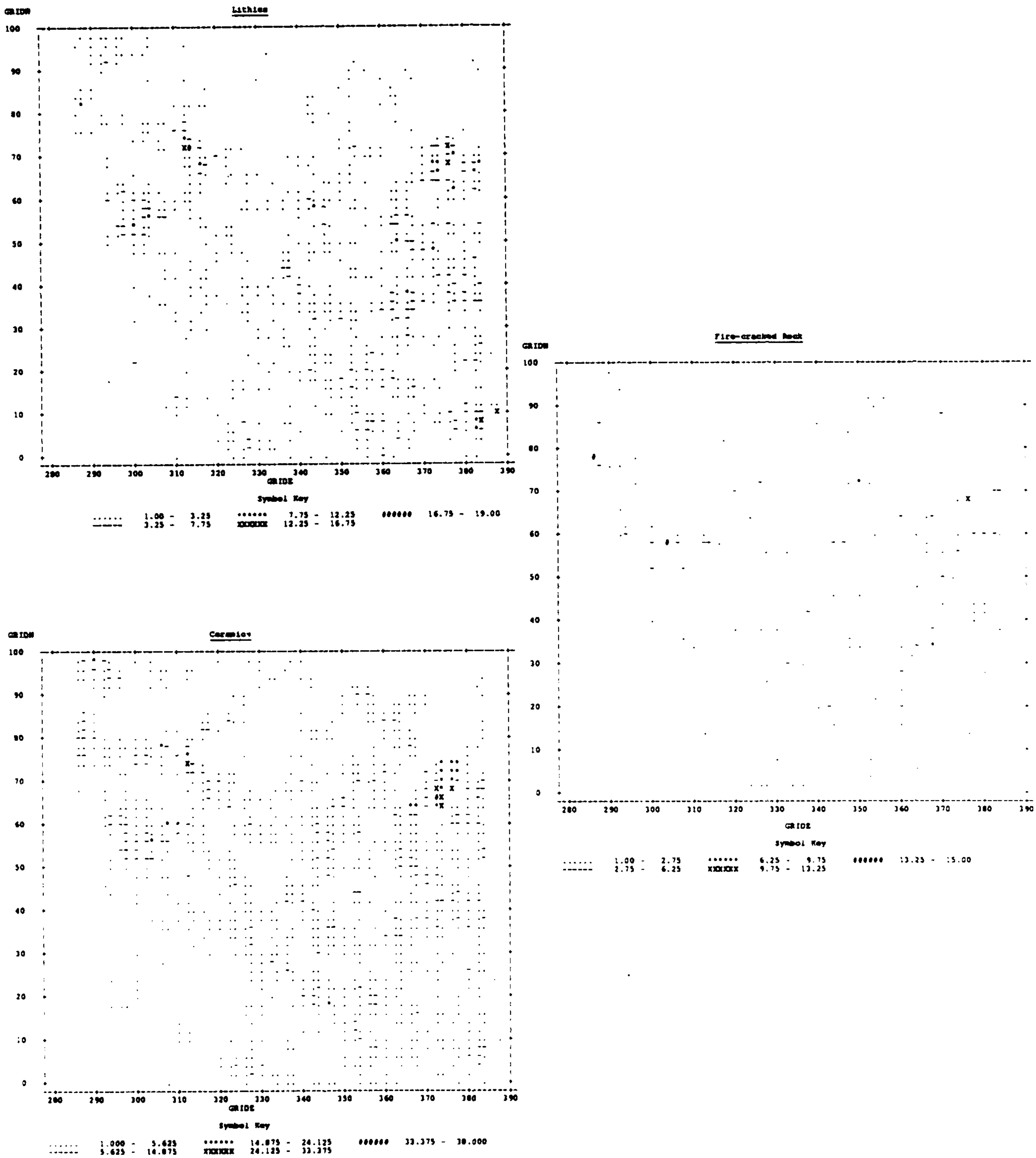


Figure 5.8. 2 × 2 meter plots of Unit 4—Phase II

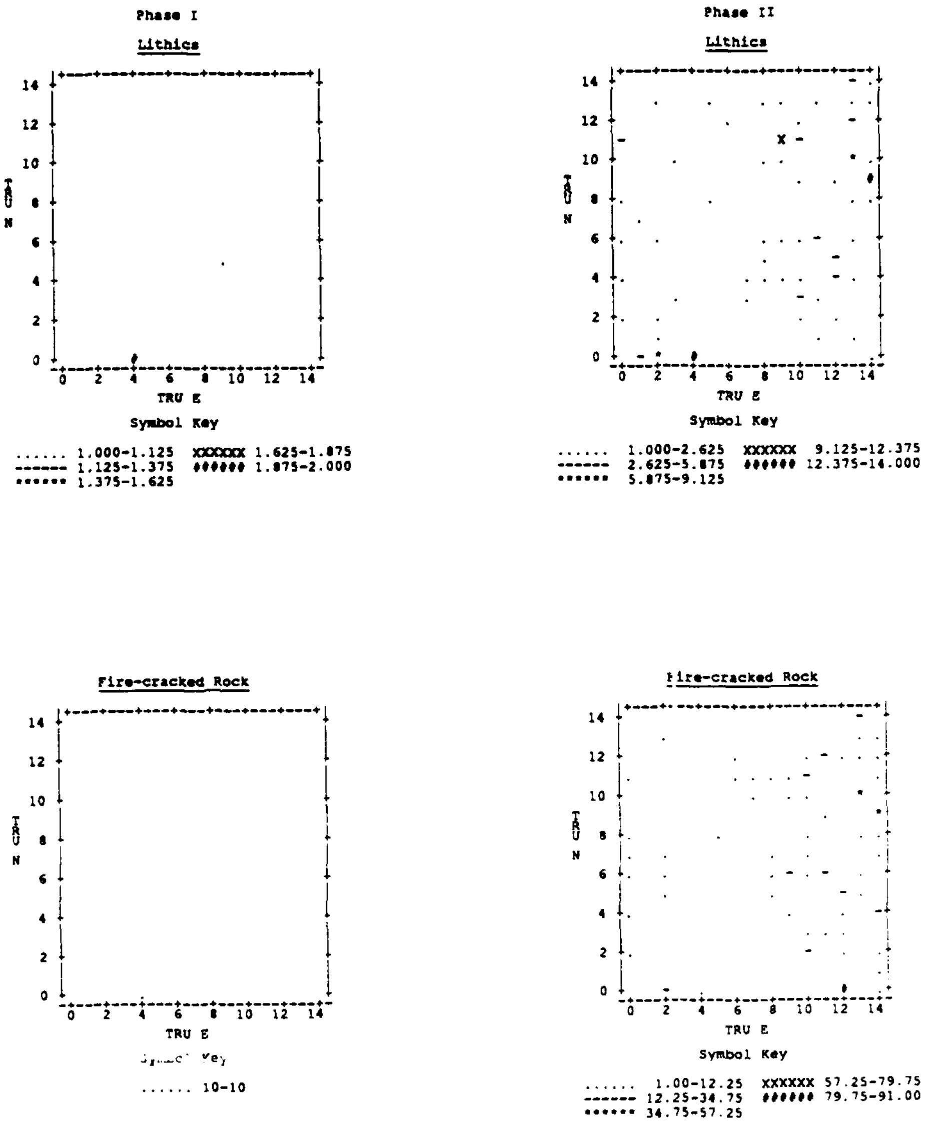


Figure 5.9. Density plots by TRU Phase I vs Phase II—Unit 1

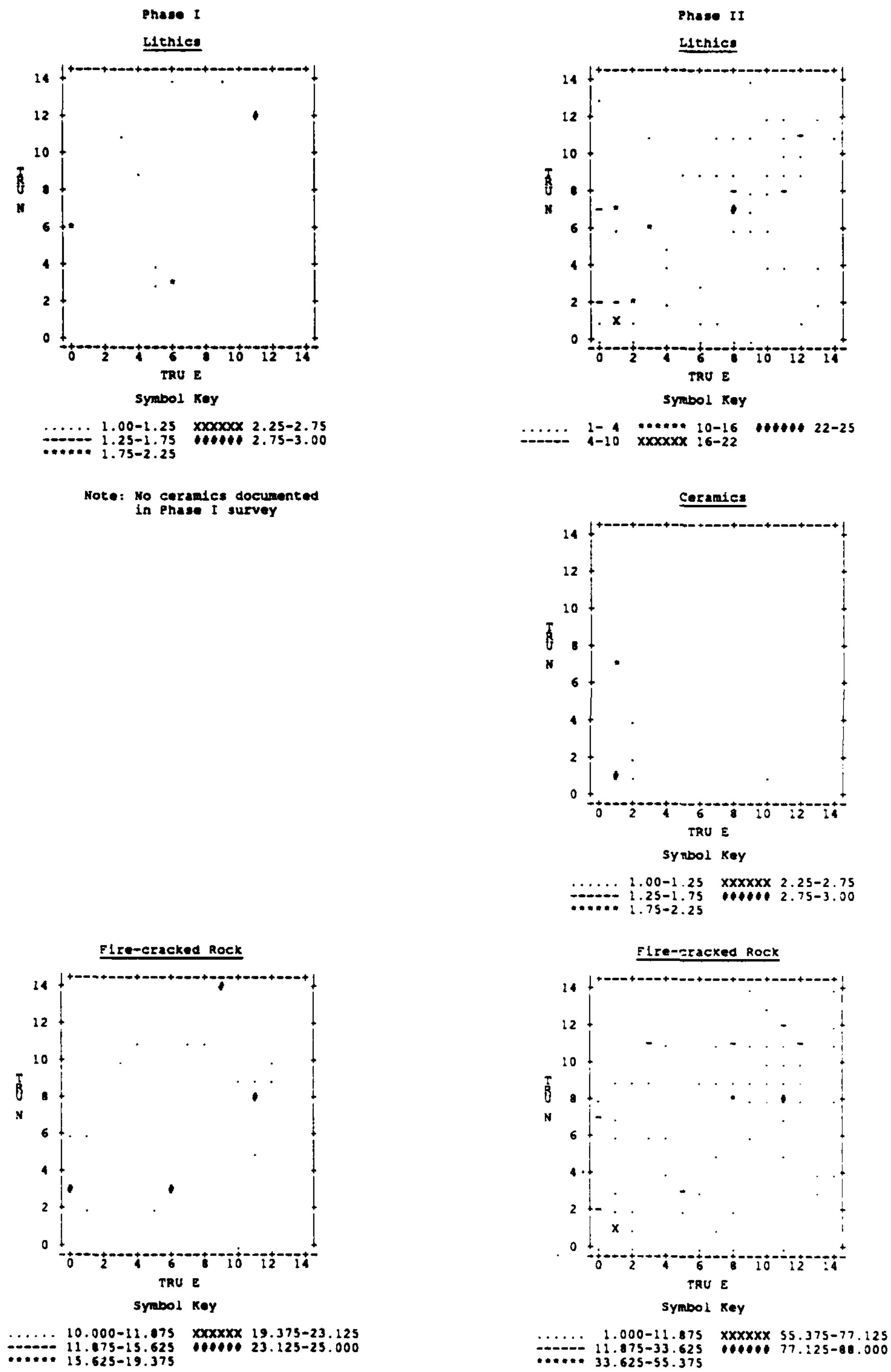


Figure 5.10. Density plots by TRU Phase I vs Phase II—Unit 5

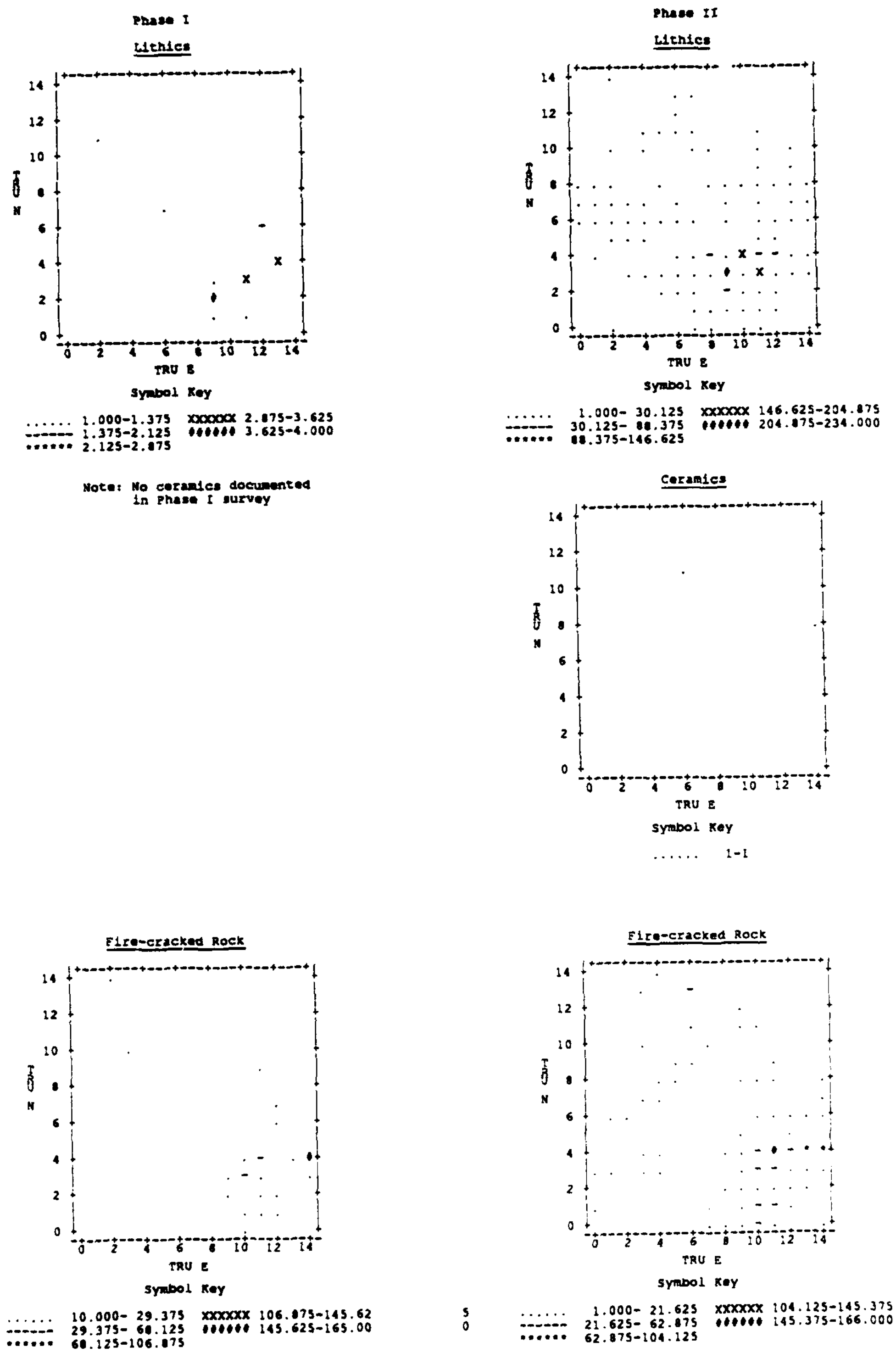


Figure 5.11. Density plots by TRU Phase I vs Phase II—Unit 2

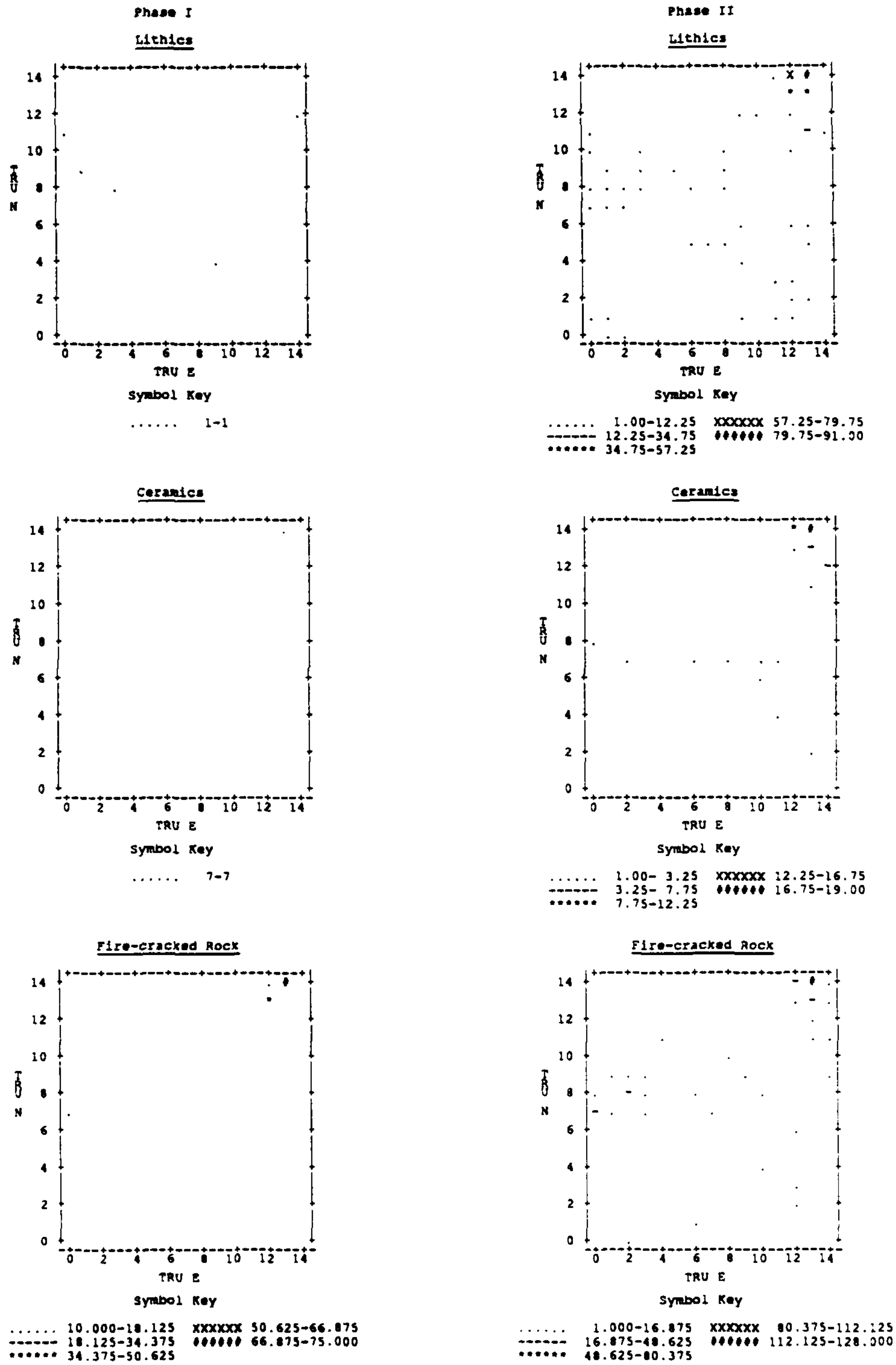


Figure 5.12. Density plots by TRU Phase I vs Phase II—Unit 6

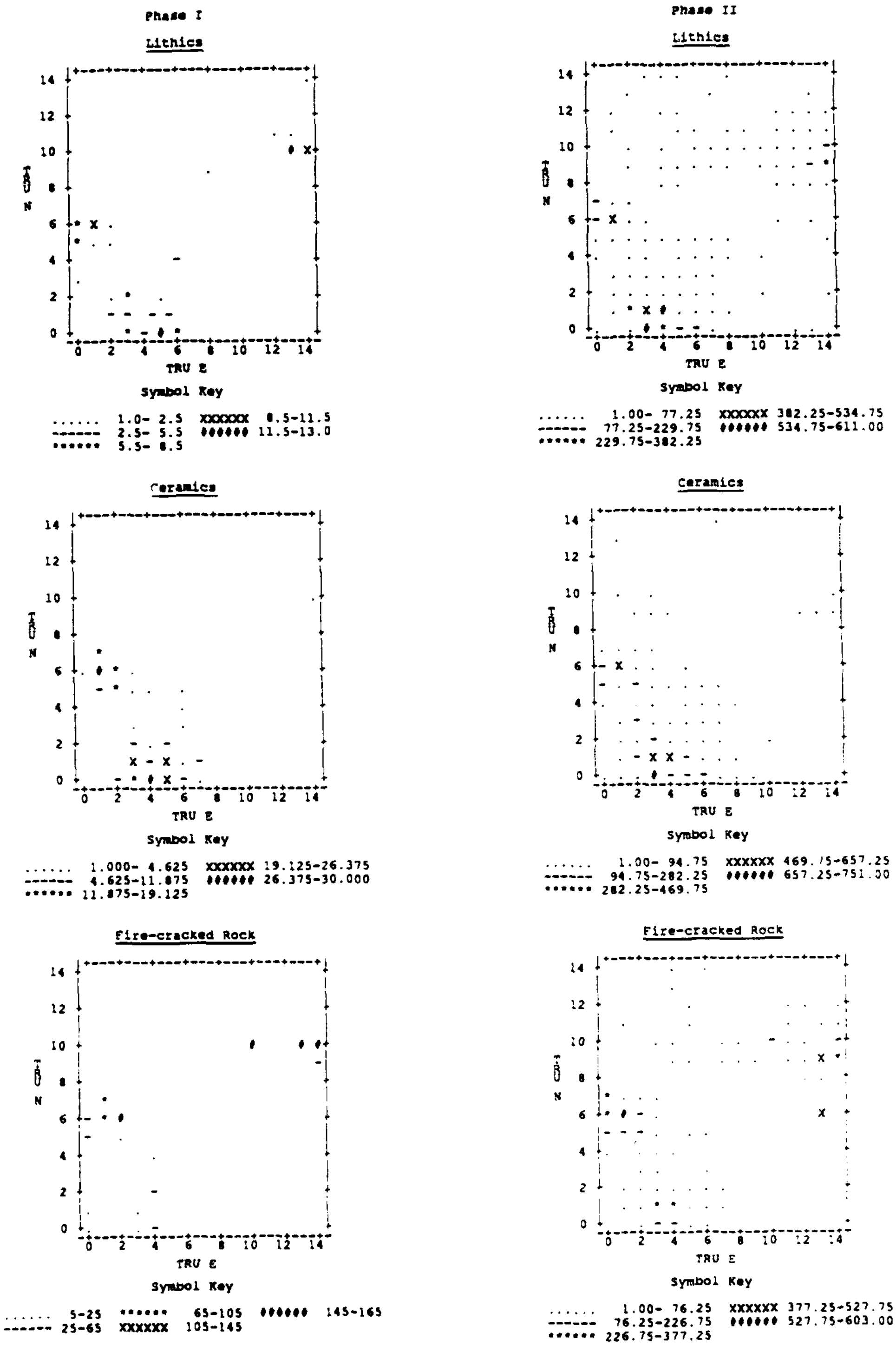


Figure 5.13. Density plots by TRU Phase I vs Phase II—Unit 3

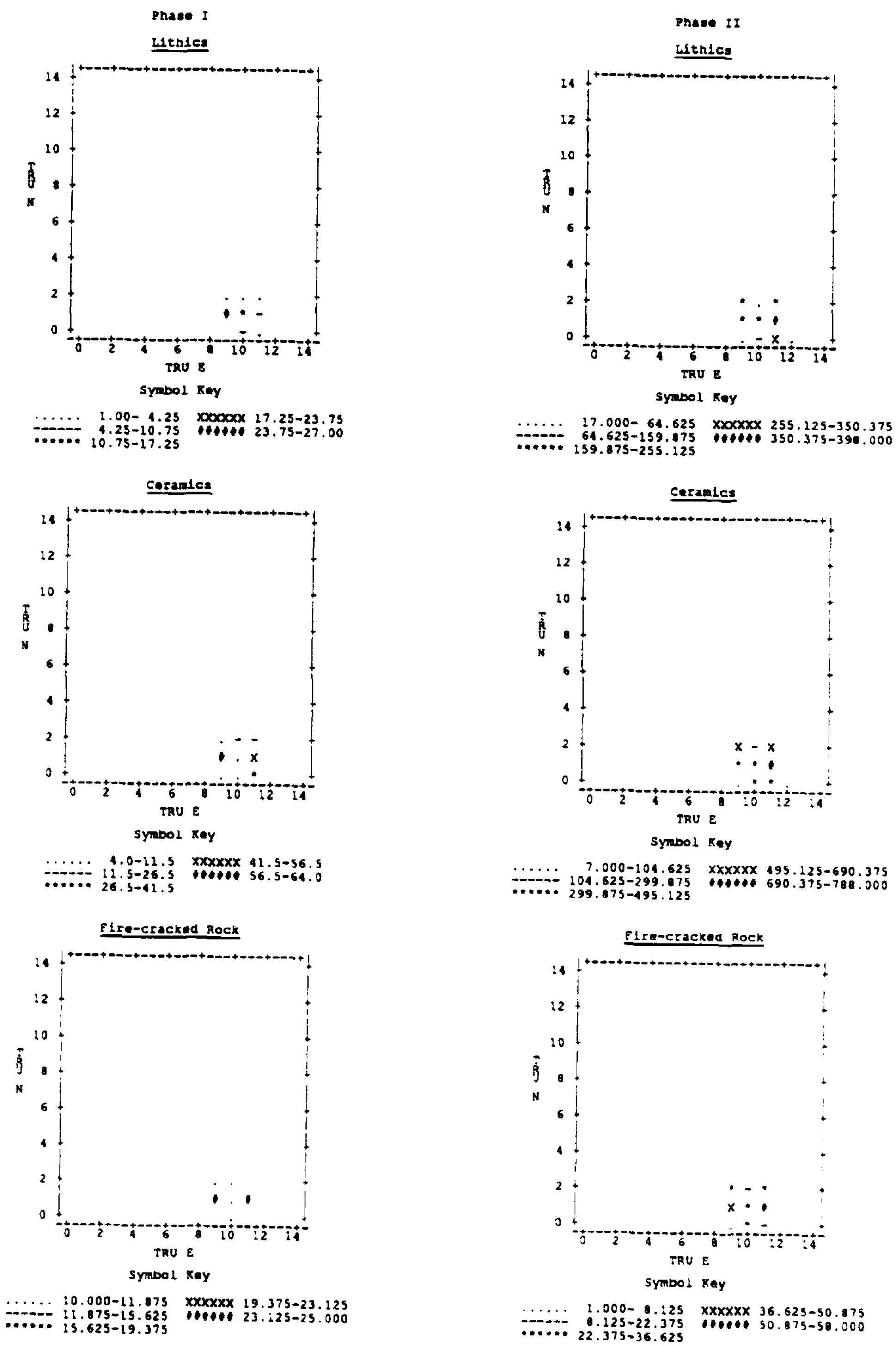


Figure 5.14. Density plots by TRU Phase I vs Phase II—Unit 4

between the Phase II distributions and the TRU estimates, it is also evident that a considerable quantity of cultural remains was missed in Phase I. This is clearest in the plots for Unit 1, where the majority of the artifacts and features were missed. The Phase I data indicate that most of Unit 1 is empty, whereas much of it actually contains a thin scatter of cultural debris consisting largely of lithics and fire-cracked rock.

An important aspect of the TRU data evident in these figures is that, for the most part, the TRU system did not miss major concentrations of artifacts and features. On the other hand, much of the low-density landscape is poorly represented. One way to view these facts is to note that high-density areas were more visible to survey crew members than low-density ones. This relationship between density and visibility has been recognized by other archeologists concerned with the reliability of survey data (Wandsnider and Ebert 1984), and it appears to be a simple function of the speed with which survey crew members cross the ground.

The preceding correlation is confirmed by the fact that much of the off-transect data recovered by the TRU system appears to be coincident with high-density areas. In simple terms, the off-transect observations were more informative about what the quantitative data had already recorded. As noted in the introduction to this chapter, off-transect data were useful in defining sites in the laboratory. In addition they served as a coarse but convenient measure of the effectiveness with which sites were sampled by the TRU system. However, the results presented here suggest that low density materials missed by TRUs are not necessarily represented in the off-transect data.

Among the kinds of data collected by these off-transect observations were estimates of the number of artifacts contained in off-transect lithic and ceramic scatters (recorded as class estimates: 1–10, 11–30, 31–100, 100–plus artifacts; see Chapter 2). In conjunction with the on-transect quantitative observations, these data were used to compute an estimated sampling fraction for Phase I sites. The on-transect quantities were added to the off-transect midpoints (5, 20, 65, and 150) to obtain an estimate of the total number of lithic and ceramic artifacts present at a site (using the sum of all TRUs recorded for a site). The result was divided into the number of artifacts actually recorded to yield the estimated sampling fraction.

Table 5.6 shows the breakdown of estimated sampling fractions for the 1551 lithic sites and 561 ceramic sites recorded in the Phase I survey. Although the figures are based on rough estimates, the pattern is clear. Fully 40 percent of the ceramic sites and 30 percent of the lithic sites are completely unknown from a quantitative perspective. Approximately two-thirds of both types of sites have estimated sampling fractions of 25 percent or less, while only about 20 percent have been sampled at rates of 50 or more percent. It should also be noted that roughly 15 percent of the sites in each type were sampled at or near the 100 percent level, a somewhat surprising statistic considering the nature of the problem. Many of these cases probably represent very small sites whose assemblages fall entirely within a single TRU. It is suspected, however, that many, if not most, of these entries are field-recording errors in which the field archeologists failed to make off-transect observations. Off-transect data were recorded in the "Features" section of the TRU forms; during data processing in the field laboratory, more errors were encountered in this part of the form than any other.

Given that even well-placed transect samples on sites are subject to dubious reliability (McAnany et al. 1984), and that the determination of reliable sampling fractions is a complex issue further complicated by variations in content from site to site (Nance 1981), one might anticipate that 50 percent would constitute a minimum acceptable sample size for estimating assemblage content in terms of various characteristics. The figures in Table 5.6 suggest that one would be ill-advised to use the Phase I site data for any but the simplest of analytical purposes.

Knowledge of assemblage content is critical to most analytical approaches to understanding past settlement and subsistence. The absence of reliable site-content data has the effect of hamstringing any conventional archeological survey for either cultural resource management or scientific purposes. The problem with the Phase I site data is that there is no way to tell which sites were adequately sampled, and which were not. As a result, there is no way to distinguish variability in assemblage content that is behavioral or temporal in origin from that which is merely a function of sampling vagaries. Many survey reports acknowledge the problems involved in adequately sampling site content, but then blithely ignore the problem when evaluating sites on the basis of quantitative analyses. We believe that the time has come to address the issues of sampling adequacy in a straightforward manner. Nothing can be productively gained by continuing to ignore the problems identified here.

The fact that the nature of the Phase I TRU data effectively eliminates sites as units of analysis is in no way resolved

Table 5.6. Estimated sampling fractions for Border Star 85 lithic and ceramic sites (Phase I)

Lithic Sites				Ceramic Sites			
Sampling Fraction	Number of Sites	Percent	Cumulative Percent	Sampling Fraction	Number of Sites	Percent	Cumulative Percent
0%	478	29.9	29.9	0%	230	39.1	39.1
1–25 %	586	36.7	66.6	1–25 %	165	28.1	67.2
26–50 %	242	15.1	81.7	26–50 %	79	13.4	80.6
76–100%	245	15.3	100.0	76–100%	87	14.8	100.0

by the nonsite perspective of the survey (Chapter 2). As originally conceived for the Border Star 85 project, this perspective treats all cultural remains as distributions to be analyzed and grouped into objective assemblages in the laboratory. These assemblages are then assumed to be associated and are analyzed as such. The use of the term "site" is practically arbitrary from this perspective.

Overall, almost three-quarters of the cultural remains discovered in the Phase I survey belong to the site category. Whether or not these sites have interpretive potential, or were defined according to any particular standard, is of little importance. What is critical is that observed aggregation and higher density were the principal criteria for their subjective definition. Unfortunately, it is just these materials that, because of their inherent aggregation and its consequences for effective sampling, are most subject to potential sampling error. Thus, the greater part of the archeological remains on the landscape appear to fall in clusters that, on the one hand, represent the greatest degree of association while, on the other, are probably the least effectively sampled.

Phase II Unit Selection

The Phase II fieldwork was conducted for two purposes: (a) to provide accurate data for the calibration process and (b) to gather in-depth information from a variety of areas representing the functional and temporal range of cultural manifestations present in the Border Star 85 area.

The main goal of the calibration portion of the Border Star 85 project was to address the effective resolution of the TRU data in terms of both accuracy and precision in estimating the content of a variety of cultural landscape types as defined on the basis of Phase I data. The process consisted of five major tasks: (a) choosing an appropriate Phase II survey unit size; (b) using the Phase I data to classify units of the given size in Area A into a limited number of landscape types; (c) choosing several units reflecting the variety evident in the classification; (d) resurveying the units chosen; and (e) comparing the Phase II data with the original data from Phase I.

An assessment of the work effort allocated to Phase II of the Border Star 85 project determined that six landscape units (consisting of five 500 × 500 m grids along with one 100 × 100 m grid in the center of a large, high-density site) could be subjected to 100 percent resurvey using high-resolution 2 m grid proveniencing.

The 500 m grid size was chosen after we inspected histograms similar to those presented in Figure 5.15 and noted that the density distributions appeared to approximate a log-normal distribution at ca. 500–1000 m (that is, they appear to approximate a Poisson distribution with a large lambda). Such a distribution is essentially random and thus unaggregated. Although this judgmental method constituted a somewhat paradoxical pre-calibration determination of effective resolution, it was a necessary precursor to using the Phase I TRU data to classify landscape units for selection.

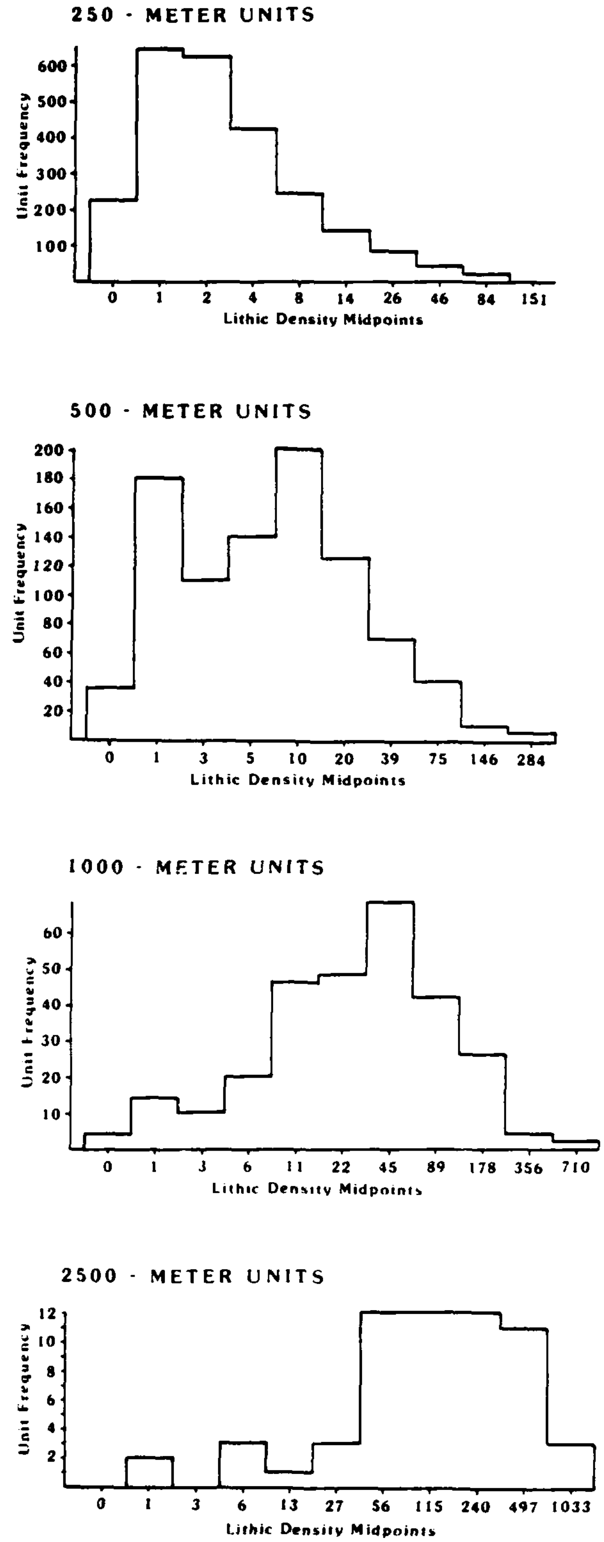


Figure 5.15. Phase I histograms of lithic densities by 250, 500, 1000, 2500 meter square areas

The decision to use 500 m units was also conditioned by the exigencies of the work effort allocated to Phase II and by a desire to visit a variety of landscape types. The 500 m size was chosen as a compromise between the larger sizes required for both the calibration effort and a reliable classification, and the smaller sizes that would allow for more individual units and thus greater variation in the nature of the areas visited.

The task of selecting six 500 m landscape units (out of 770 possible in Area A) that are representative of variation in two major, perhaps uncorrelated, sets of dimensions might be considered difficult if not impossible. In order to make this task easier, the Phase I data (summarized by 500 × 500 m grids) were subjected to a cluster analysis using the average linkage method. The 500 m units treated in this fashion were defined using the UTM system and represent quarter square kilometers aligned with major 1000 m UTM lines.

As the most common form of numerical taxonomy, cluster analysis offers the advantages of both objectivity and increased efficiency in quickly grouping cases together on the basis of similarities in quantitative attributes. The average linkage method was chosen on the basis of its tendency to minimize within-cluster variance. The resulting cluster solution is based on an inspection of the values of the *cubic clustering criterion* (CCC) and the choice of the smallest number of clusters for which the CCC reached a "peak" at a value greater than two (SAS Institute 1982b:417–420).

For calibration purposes, the goal of the cluster analysis was to classify the 500 m units in Area A using attributes indicative of the three aspects of spatial distributions thought to have the greatest effect on cluster sampling methods: density, ubiquity, and degree of aggregation. Four variables, computed from the Phase I data, were used in the cluster analysis:

1) Total number of observed lithics, ceramics, and features evidencing use of fire (on-transect only; counts not adjusted for the 6 percent sampling fraction);
2) Total number of site TRUs (i.e., TRUs from identified sites);
3) Ratio of site TRUs to all cultural TRUs (that is, all TRUs with on- and/or off-transect observations of any cultural materials);
4) Total number of sites recorded in the unit.

Variable 1 represents the overall density of the cultural landscape. The three data classes were combined in order to restrict the number of clusters (or types) in the resulting solution. Variables 2 through 4 were included as related measures of ubiquity and aggregation based on the realization that subjectively identified sites constituted a convenient in-field method for diagnosing the presence of aggregated, high-density cultural remains. The site TRU is a measure of aggregation and clustered density in that it represents the amount of space occupied by clustered materials. The site-to-cultural TRU ratio measures overall dispersion in terms of the proportion of unaggregated cultural remains. Total site count was included as a measure of cluster density and, to some extent, as an inverse measure of relative site size.

Once the cluster analysis had defined landscape types, the units in various type classes were reviewed in an attempt to choose specific units that were at least partially representative of the major cultural phases present in the Border Star 85 area: Archaic, Mesilla, and El Paso. Paleoindian sites were rare; one discovered in the course of the survey is documented in Chapter 17. Other considerations in the selection process included unit-to-unit variation in artifact content (e.g., lithics vs ceramics) and location with respect to major differences in environmental parameters. Although the final choices for the Phase II survey may not be a truly valid sample of the total range of variation within the survey locale, it is hoped that the essential elements of variation are represented.

From the above discussion it should be clear that the classification of 500 m grids derived by the cluster analysis is much more representative of variation related to calibration issues than it is of an undoubtedly complex array of functional and temporal variables. As the results of analyses presented in Chapters 7 and 8 suggest, there is far too much variability in behavioral elements to be represented adequately in a sample such as that provided by the five 500 m units and the one hectare that were used to collect the Phase II data.

The cluster analysis of the Area A 500 m grids resulted in the definition of 18 clusters or landscape types. Means (*cluster centroids*) for the variables used in the analysis are presented for the 18 clusters in Table 5.7. Also included are means for several other variables that reflect relevant aspects of landscape content: total lithics, ceramics, and features; site size (in TRUs); and cultural TRUs (a measure of occupied space). As is common in archeological situations (Doleman 1985), a few types account for most of the variation present. For example, Clusters 1 and 3 constitute over 87 percent of the units analyzed. These statistics also reflect the conclusions drawn in the previous section: that is, by far the greater part of the Border Star 85 landscape consists of aggregated, low-density distributions of cultural remains. Both high density and dispersed distributions are rare patterns.

Nonetheless, it is clear that there is considerable variation in landscape structure and content in the Border Star 85 survey area. Figure 5.16 presents schematic representations of the distributional structure of the 18 cluster types, with shaded areas representing sites and large dots (not the grid of small dots which is included for scale) representing isolated occurrences or off-site phenomena. These modal cluster configurations were derived from the statistics in Table 5.7 to provide a graphic depiction of the cluster analysis results.

Figure 5.17 shows the distribution of the 18 landscape types in Area A. Each character in the plot represents one 500 m grid and its cluster designation (1–9 = Cluster 1–9; 0 = Cluster 10; letters A-H = Clusters 11–18). The large blank areas on the east side of the map represent the steep, unsurveyed portions of the Jarilla Mountains. This map shows that variation in landscape structure is continuous and complex. Undoubtedly, some of the mixing of types apparent in the map (and some of the classifications themselves) is a function of the imposition of an arbitrary grid

Table 5.7. Attribute means for the 18 landscape types defined in Area A

		Clustered Variables								
Cluster Number	No. of 500 m Grids	L/C/F Total	Site TRUs	Site/Cult TRU Ratio	No. of Sites	Total Lithics	Total Ceramics	Total Features	Site Size (TRUs)	Cultural TRUs
1	372	12.9	0.7	0.08	0.5	6.6	3.6	2.7	0.6	7.4
2	18	6.6	2.3	1.00	1.4	3.1	1.4	2.1	1.6	2.3
3	265	34.6	5.8	0.50	3.2	16.7	10.3	7.6	2.2	13.1
4	43	84.6	13.7	0.58	7.2	34.9	35.3	14.4	2.0	24.7
5	18	97.7	17.9	0.59	11.2	54.8	18.3	24.5	1.6	30.4
6	15	172.5	19.7	0.71	1.6	44.5	107.7	20.3	15.7	29.9
7	9	91.3	26.6	0.85	5.3	33.9	25.6	31.9	5.2	32.0
8	11	303.1	38.1	0.86	2.5	86.9	179.7	36.5	23.2	44.5
9	4	529.5	67.3	0.84	1.8	86.5	414.8	28.3	42.0	80.3
10	3	238.3	62.3	0.91	5.0	56.0	115.0	67.3	12.8	68.7
11	2	230.5	44.0	0.83	12.5	45.5	118.0	67.0	3.5	53.5
12	2	478.5	97.5	0.92	2.5	148.0	184.5	146.0	61.1	106.0
13	3	1145.0	41.0	0.79	2.7	242.0	868.7	34.3	16.5	52.3
14	1	471.0	35.0	0.74	9.0	62.0	359.0	50.0	3.9	47.0
15	1	513.0	21.0	0.42	14.0	161.0	307.0	45.0	1.5	50.0
16	1	70.0	25.0	0.74	16.0	39.0	0.0	31.0	1.6	34.0
17	1	671.0	11.0	0.50	4.0	105.0	558.0	8.0	2.8	22.0
18	1	3688	116.0	1.00	1.0	904.0	2732	52.0	116.0	116.0
All Grids	770	51.1	6.2	0.33	2.3	18.5	24.6	8.0	2.6	13.5

system on the underlying distributions; however, a basic pattern is evident. Low-density grid types such as Clusters 1–3 predominate in the western part of the area, while most of the rare, high-density grids appear to be nearer the mountains. The cluster of large sites in the Monte Carlo Gap area is clearly visible in the east-central portion of the map, which suggests that landscape structure is correlated to some degree with environmental factors.

These graphic displays, together with the statistics in Table 5.7 and ancillary data concerning the documented temporal associations of sites in the individual units, were used in choosing the units for the Phase II portion of the Border Star 85 survey (see Chapter 8 for an in-depth discussion of Phase II unit cultural and temporal associations).

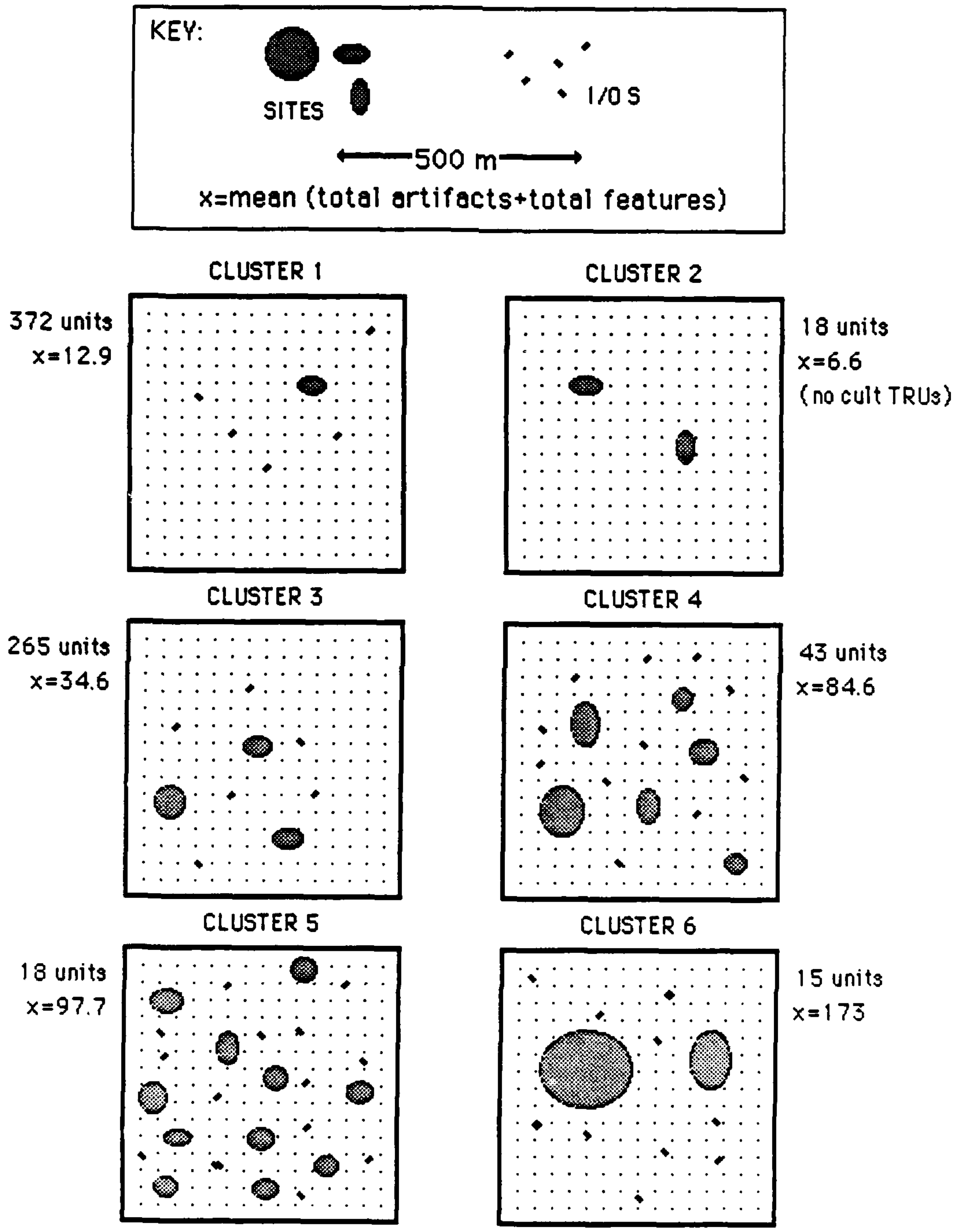
Based largely on the variations reflected in Figure 5.16, four clusters were chosen as best representing the range of variability in landscape content revealed by the analysis: Clusters 1, 3, 8, and 18. Two units each were chosen from Cluster 1 (Units 1 and 5) and Cluster 3 (Units 2 and 6) in order to achieve good representation of the most common Border Star 85 landscape types. Cluster 8 (Unit 3) was chosen as the best possible average of the variability present among the denser cluster types, especially those with larger sites. Finally, a portion of the grid classified into Cluster 18 (Unit 4) was chosen to represent the extreme conditions present in the center of a large, high-density site.

Phase II Evaluation of Phase I Survey Data

The actual choice of the particular 500 m units for Phase II survey resulted largely from a subjective elimination process incorporating the culture/time period and locational considerations outlined above. Table 5.8 presents

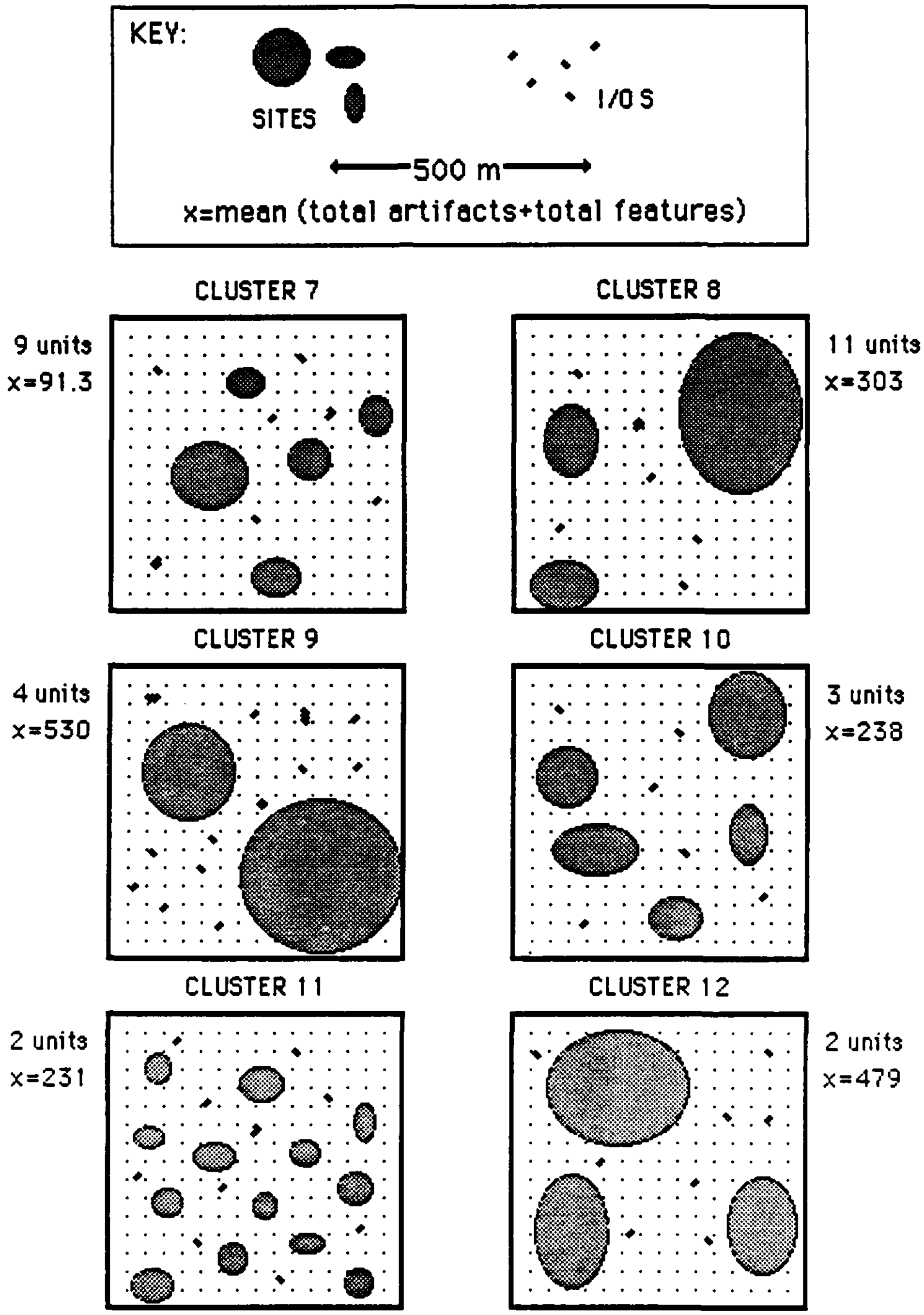
Table 5.8. Phase II units: Artifact counts and site attributes (Phase I and II)

		Phase 1 Data							Phase 2 Data				
						Expected					Actual		
Unit	Cluster	Sites	Site Area	Site TRUs	Cult TRUs	Lithics	Ceramics	FCR	Sites	Site Area	Lithics	Ceramics	FCR
1	1	1	870	1	3	50	0	15	8	860	140	0	521
5	1	1	870	1	24	217	0	270	6	1744	172	9	558
2	3	2	10470	12	27	283	0	315	7	15143	1151	2	913
6	3	2	3490	4	9	83	117	105	7	2066	379	57	367
3	8	3	27047	31	42	1967	4401	330	10	56218	4864	4977	5473
4	18	1	100000	9	9	1017	3633	32	1	100000	1728	3730	253



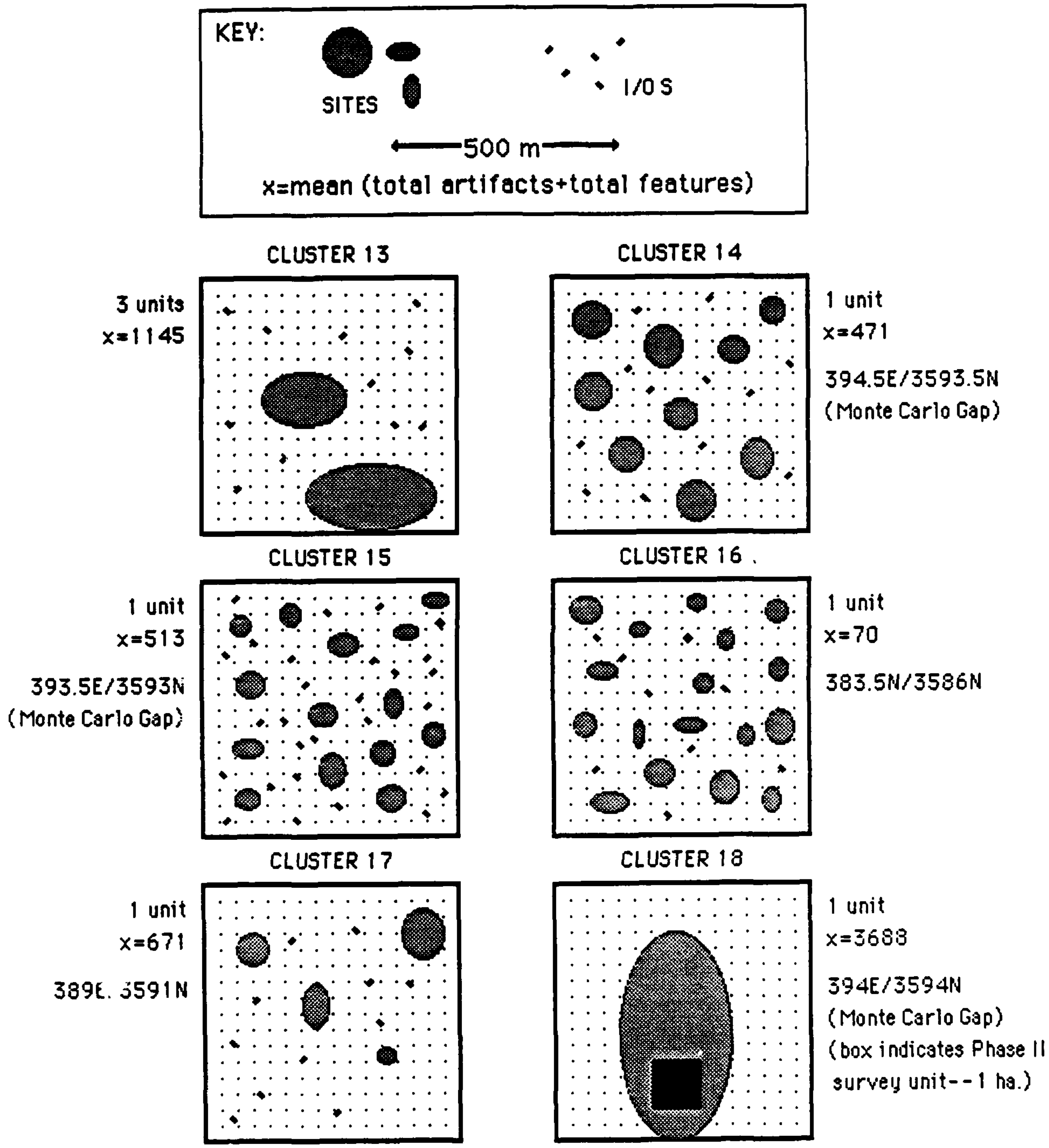
NOTE: These are schematic representations of the central tendencies of each cluster.

Figure 5.16. Model cluster configurations



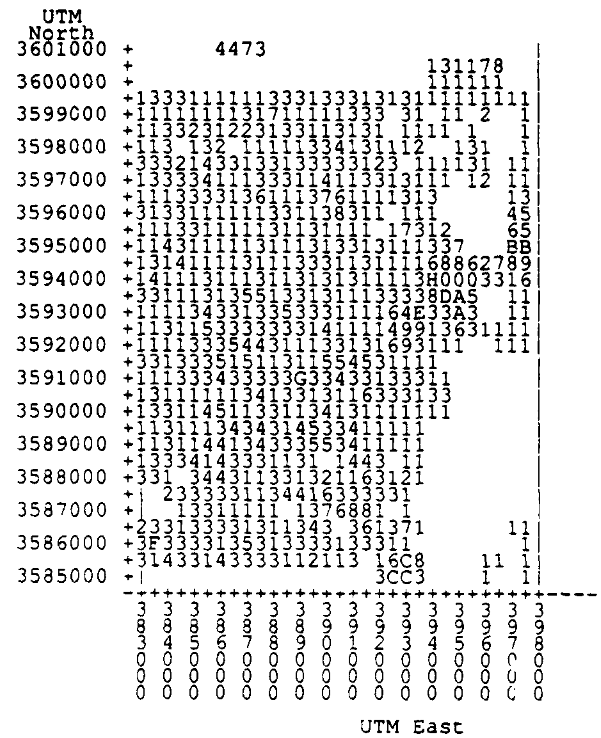
NOTE: These are schematic representations of the central tendencies of each cluster.

Figure 5.16. (continued)



NOTE: These are schematic representations of the central tendencies of each cluster.

Figure 5.16. (continued)



Note: "A"=11, "B"=12, etc.

Figure 5.17. Distribution of cluster types in Area A 500 × 500 meter units

the final Phase II units surveyed along with summary data from both Phases I and II. Site area totals are in square meters. Phase I site areas were estimated by multiplying the number of TRUs in which a site was located by the area of a circle 33.3 m in diameter. Phase II site areas were calculated by using their length and width in the formula for the area of an ellipse (Chapter 7). Phase I artifact count estimates (expected) include adjustment by a factor of 16.7, which represents the inverse of the sampling fraction of 6 percent. The Phase I fire-cracked rock estimate is based on the on- and off-transect fire-cracked rock estimates. Site area totals for Phase II data are based on computations described in Chapter 7.

The data in Table 5.8 reveal both the nature of the units surveyed in Phase II and the degree of error inherent in the TRU sample. The Phase I figures (see also Table 5.7) clearly show how the clusters vary in cultural content. Units 2 and 6 (Cluster 3) are more dense and have higher site counts and greater total site area than Units 1 and 5 (Cluster 1), but all four units are far less dense than either Unit 3 (Cluster 8) or Unit 4 (Cluster 18). It should be noted that the totals for Unit 4 are from an area only 1/25 the size of the other units.

Table 5.9 shows the actual artifact densities (per 100 sq m) present in the six Phase II units. As with the other statistics, these figures reveal the vast differences in density that exist across typical archeological landscapes and

Table 5.9. Phase II lithic, ceramic, and FCR densities

		Artifact Class		
Cluster	Unit	Lithics	Ceramics	FCR
1	1	0.056	—	0.208
1	5	0.069	0.004	0.223
3	2	0.460	0.001	0.365
3	6	0.152	0.023	0.147
8	3	1.946	1.991	2.189
18	4	17.280	37.300	2.530

again show how the four clusters or landscape types differ in general content. Even Clusters 1 and 3 differ, although the disparities between these and the other two are considerably greater. Differences in the degree of aggregation between Clusters 1 and 3 are evident in the ratios of sites to cultural TRUs (Table 5.7).

Overall, the six units reflect variation along a complex dimension from dispersed low density distributions to aggregated high density distributions. In conventional archeological parlance, this represents the spectrum defined by isolated occurrences on the one hand and large, dense sites on the other. The fact that the variation is continuous is important given the usual tendency for archeologists to divide the empirical record into categories.

Table 5.8 also indicates the magnitude of the differences between estimates derived from the TRU sample and the 100 percent sample provided by the Phase II survey. With two exceptions, when adjusted for the sampling fraction the TRU data consistently underestimated the cultural remains actually present. Perhaps most surprising were the differences in the number of sites recorded. Eight Phase II sites were recorded in Unit 1, during Phase II survey, yet only one site was encountered in Phase I. Thus, only one-eighth of the sites present were discovered by the TRU system. Similar, but less severe, differences are apparent for the other units. Some are a function of the differences between the methods of site definition used in Phases I and II, and possibly of geomorphically conditioned visibility, e.g., one Phase I site each from Units 5 and 6 could not be relocated in Phase II (Chapter 7). Many of the differences, however, are a product of the Phase I methodology and the low visibility it afforded small, low-density artifact scatters.

Although there is considerable variation in site area estimates (mostly a function of differences in methods of area estimation) the overall discrepancies in site area estimates are less severe. In one case (Unit 6) two small sites totaling four TRUs resulted in the gross overestimation of site area as a function of the use of the TRU as the minimal recording unit. Nonetheless, the trend is clearly toward the underestimation of site area.

Finally, with the exception of ceramics from Units 4 and 6 and Unit 5 lithics, it is clear that the TRU data underestimated the densities of all three major artifact classes. Although the figures indicate that fire-cracked rock values suffer from the greatest discrepancy, the differences result in part from the use of scatter estimates to compute the Phase I counts.

Table 5.10. Phase I/Phase II estimation proportions for Phase II units by type

Unit(s)	Sites	Site Area	Lithics	Ceramics	FCR
1	0.13	1.01	0.36	1.00	0.03
5	0.17	0.50	1.26	0.00	0.48
2	0.29	0.69	0.25	0.00	0.36
6	0.29	1.69	0.22	2.05	0.29
1/5/2/6	0.21	0.79	0.42	0.30	0.30
3	0.30	0.48	0.40	0.88	0.06
4	1.00	1.00	0.59	0.97	0.13

In order to reveal trends in the relationship between the TRU data discrepancies and landscape factors such as density, Table 5.10 presents the TRU estimates as proportions of the Phase II values for sites, site areas, and the three artifact classes. Values less than 1 indicate underestimation, while values greater than 1 reflect overestimation. Statistics for Units 1, 2, 5, and 6 grouped together are also provided as an estimate of the error for the most common landscape types in the Border Star 85 area. As might be expected, areas with larger and more dense sites and greater overall site density exhibit less error in site count estimation. In other words, site discovery is more reliable when sites are larger and more dense. There is no clear relationship for estimates of site area, but if Unit 4 is excluded (since the entire site is not included in the sample), comparison of Unit 3 with the others suggests that the error is greatest for areas of moderate density and site size and count, for example, Unit 3.

With the exception of the slight overestimation of lithics in Unit 5, Table 5.10 suggests a pattern of more reliable lithic count estimates associated with increased densities (the Unit 5 and 6 overestimates probably reflect the hit-or-miss nature of the TRU sample in low density areas). For fire-cracked rock the degree of underestimation appears to increase with increasing density (Table 5.9). Ceramic estimation appears variable at low densities and markedly more reliable with increasing density and aggregation. This fact is perhaps consistent with the discovery that, in general, ceramics as a class of artifacts exhibit more aggregation. Similarly, the apparent lack of a pattern for lithic count estimation may reflect the relative ubiquity of these artifacts.

Generally, lithic and especially ceramic count estimate reliability appears to increase with increasing density, while fire-cracked rock estimates become less reliable. Differences in these trends are probably related to differences in distributional structure (e.g., aggregation in ceramics) and to variations in on- and off-site visibility of the different artifactual classes. Other factors affecting estimation error may include variations in personnel skills, time of day observations were made, and wind-induced high frequency variations in visibility (sand dune cover).

Although the analysis described above involved the somewhat risky process of using uncalibrated TRU data to classify the landscape, the cluster analysis and the TRU data upon which it was based appear to have successfully diagnosed at least gross elements of landscape content and structure. Comparison of the actual archeological distributions, shown in Figures 5.2–5.7 (the Phase II data from Units 1–6), with the modal cluster types in Figure 5.16 and the descriptive statistics in Table 5.7 indicates that the actual landscapes were reasonably approximated by the types generated by the cluster analysis. Thus, while the TRU data clearly suffer from underestimation, they appear to be at least moderately successful—at the 500 m level of resolution—in monitoring landscape structure, a fact that serves as further tentative confirmation of 500 m as the minimum effective resolution of the TRU data.

Chapter 6

CALIBRATION OF PHASE I DATA: EFFECTIVE RESOLUTION

William H. Doleman

Introduction

The purpose of this chapter is to determine the limitations of the Phase I survey data as a sample of the archeological landscape. Two approaches are taken. In the first, the mathematical characteristics of a quadrat cluster sampling design imposed on an aggregated spatial distribution are considered in terms of the kinds of information for which archeologists sample in survey. In this process, referred to as *theoretical calibration*, the attributes of the target population and the sampling design are compared in order to estimate the effectiveness of the design.

The second approach involves comparing the sample results (Phase I survey data) with the target population (as known from Phase II survey data) at various levels of resolution in order to determine the point at which significant variability in the amount of error or discrepancy between the two begins to disappear. This approach, referred to as *empirical calibration*, relies on the fact that as the sample data are grouped into larger grid units, the variability in the error declines. In the present study, sample data consist of individual transect recording units or TRUs, while variability in the error is measured by the difference between the Phase I TRU sample estimate and the corresponding Phase II estimate.

The goal of these two approaches is to determine the level at which the Border Star 85 TRU data can be grouped to provide reliable estimates of actual landscape content. Traditionally, survey analyses focus on comparisons of site contents for both research and management purposes. In the present case, however, such analyses are precluded for several reasons:

1) The Phase I TRU data constitute samples of site content that vary considerably in reliability. Furthermore, the degree of error for a given site is unknown (although the sampling fraction can be estimated by comparing on-transect quantitative data with off-transect observations).
2) There are good theoretical grounds for expecting that many of the observed assemblages in the project area are palimpsests of cultural remains resulting from multiple events, and that, as such, they cannot be interpreted using traditional approaches to the analysis of assemblage content (Doleman 1985; Ebert 1985).
3) Many of the sites discovered in the survey undoubtedly result as much from the operation of geomorphic processes (i.e., they represent eolian windows on a more continuous distribution) as of behavioral ones (Doleman 1985).

Finally, analysis of the Phase I data (Chapter 5) led to the conclusion that the TRU data also fail to reflect consistently the true nature of the sampled distributions as originally conceived in the remote sensing model of the TRU system. In this sense pixels larger than 33.3×33.3 m quadrats sampled by the TRUs are required to gain a consistent picture of the archeological landscape. As a result of these realizations, the following analysis was conducted with the goal of discovering a level of resolution (grouping of TRU units) at which sample reliability lies within acceptable limits. The results indicate that such a level is achieved at a scale of resolution at which TRU data are grouped into grids 250–500 m on a side. The utility of such a scale for behavioral analyses has yet to be determined, but determination of that utility can be proposed as a suitable subject for middle range theory development.

Theoretical Calibration

The information and analyses presented in Chapter 5 can be summarized as follows: The Phase I TRU data constitute a cluster sample of mostly aggregated cultural remains. Although *effective aggregation* is less at larger grid sizes and higher densities, aggregation appears to be present in the Border Star 85 data at scales ranging from as low as 2 to as high as 4000 m on a side. One result of this aggregation is that most of the sites present in the survey area have apparently been ineffectively sampled by the specific technique employed during Phase I survey, thus precluding their use as units of analysis in the traditional sense. As aggregates, sites contain roughly three-quarters of the cultural remains occurring on the archeological landscape; thus some 75 percent of the total materials in the area are potentially subject to the kinds of sampling error that cluster sampling methods and aggregation tend to produce.

Another aspect of the Phase I data, which may or may not be a product of aggregation, is the overall tendency to underestimate artifact densities; however, the degree of underestimation varies with the nature of the distribution being sampled. Finally, some evidence exists to suggest that this sampling problem may be at least partially ameliorated at grid sizes of 500 m or more, a possibility which in turn reflects the fact that the effective ubiquity increases while effective aggregation decreases in relation to increasing grid size.

Archeological survey data are generally concerned with three kinds of information: a) presence/absence of cultural remains or discovery; b) quantity of cultural remains; and c) location of cultural remains (see below). The locational resolution and accuracy of the data recorded on the Phase I survey are known: all quantitative data were recorded by the $33^1/_3 \times 2$ m TRU. This section addresses the theo-

retical reliability of the Phase I data in terms of several common archeological measures of surface remains: a) single and multiple item discovery probabilities (multiple item discovery is the joint discovery of more than one type of artifact or feature when present); (b) site discovery probabilities; and (c) proportional estimates (estimates of the proportion of a content class, such as site debitage, accounted for by a particular content type such as flakes).

The sampling error inherent in the TRU data is a function of the variability in the individual TRU estimates. This variability is a product of the "hits and misses" that result from imposing a regular quadrat system on aggregated data. Hits overestimate density, while misses underestimate it. The problem can be put in perspective by noting that if the only artifacts in the area represented by a given TRU happen to fall within the boundaries of the TRU (a hit), the resulting density estimate for the 33.3 × 33.3 m quadrat sampled by the TRU will be inflated by a factor of 16.7, or almost 1700 percent. On the other hand, if a cluster of artifacts is missed completely, the density will be underestimated by 100 percent. Thus, one effect of aggregation on spatial cluster sampling is to vary drastically the *element sampling fraction* (i.e., the proportion of the target population actually represented in the sample). The most important effect of cluster sampling aggregated data, however, lies in the tremendous increase in the variance of the estimate that results.

The two standard measures of sample quality are accuracy and precision. As noted in Chapter 5, accuracy reflects the average correctness of a particular sampling design, and precision is a measure of how redundant it is. Both measures are based on the concept of a sampling distribution.

A sampling distribution is a mathematical function that specifies the expected distribution of sample parameter estimates and associated probabilities under the assumption of random sampling for a given sample size. Thus, the sampling distribution represents the distribution of parameter estimates (e.g., sample means) that would result from drawing an infinite number of random samples from a known population (e.g., with mean *mu*, for which the individual sample means are estimated) (Blalock 1979:179–180). When there is no bias in the sampling design (true random sampling) or in its implementation, the mean of the sampling distribution will be the same as that of the population, and the design is deemed highly accurate. In other words, the difference between the average sample estimate and *mu* will be zero.

Precision, on the other hand, reflects the degree of dispersion of individual sample estimates around the sampling distribution mean, regardless of how that mean differs from *mu*. According to Cochran (1977:16), "Accuracy refers to the size of the [individual sample] deviations from the true mean *mu*, whereas precision refers to the size of the deviations from the mean *mu* obtained by repeated application of the sampling procedure." Thus, precision can be defined as the variance of the estimate, or the variance of the individual sample estimates around the sampling distribution mean. The sampling distribution variance is estimated by the variance of the sample estimates themselves. For this analysis, accuracy is defined as the degree to which the sample estimates differ from the actual population value, while precision is the variance among the sample estimates.

In general, the precision of a sample is the critical factor in determining its reliability. Provided the degree of inaccuracy (bias) is known, an inaccurate sample estimate can be adjusted. An imprecise estimate can never be adjusted, however, since the required adjustment factor is itself a random variable, the average value of which is large in comparison to the parameter to be estimated.

The sampling problems associated with the TRU system and the goals of the calibration analysis can thus be redefined in theoretical terms. First, preliminary evidence suggests that the system is inaccurate and underestimates landscape content. Second, cluster sampling in general is less efficient than element sampling, and it suffers from reduced precision and higher variances (Cochran 1977:233). Third, aggregation in the target distribution further increases the variance of the estimate by increasing the variability among individual cluster sample sizes (or element counts) and thus in the individual estimates of the population element total (see below). Fourth, the grid units that result from grouping TRU data into larger (square) grid units represent cluster samples consisting of N clusters, where N is the number of TRUs in the grid. Finally, for purposes of empirical calibration, increasing grid size is expected to reduce the variance of the estimate and thus increase precision as a result of increasing both the number of clusters (N) and the number of elements (*n*) included in the resulting sample.

Cochran (1977:21) states that four essential population characteristics are usually of interest in sampling: the mean, the total, the ratio of two totals or means, and the proportion of units in some category. While the third characteristic is uncommon in the analysis of archeological assemblages, the other three are frequently encountered. Thus, the TRU data from a grid might be used to estimate mean flake length, the total number of flakes, or the proportion of all items falling in the flake category. The appropriate formulas for computing the variance of the estimate vary from one measure to another and are also dependent on the sampling method involved.

Nance offers a simplified version of this classification, which is appropriate to most of the archeological measures encountered in the literature. Nance divides archeological sampling into two types: discovery and statistical precision (1981:152). Discovery sampling is essentially sampling for the presence of a target item or items and can be divided into individual and multiple discovery models. Discovery sampling is important when presence/absence data are needed or are insufficient (as in discovering chronological markers); it is critical when the target phenomena are rare for it may be the best method the archeologist can use. The statistical precision model, on the other hand, refers to the precise estimation of population proportions and is appropriate to many analyses of assemblage content. In a general sense, Nance's statistical precision model applies to all cases in which reliable sample estimates of population parameters are of interest.

The mathematical theory relevant to sampling for various types of archeological measures is generally quite com-

plex. As a result, the empirical calibration described in this chapter addresses only one type of measure: estimation of the population total or that loosely referred to here as calibration of the counts of various classes of cultural remains. The decision to calibrate the TRU data in terms of count estimates was based on the notion that most other assemblage attributes (e.g., proportions) are computed from counts or count estimates.

The apparent effects of the TRU system on estimates of site content have been discussed in the previous section. Some theoretical elements of discovery and proportional estimate sampling are discussed below prior to the presentation of the empirical results.

Sampling for Single Item and Multiple Item Discovery

In simple terms, Nance's discovery model of sampling involves the evaluation of spatial sampling designs in terms of their effectiveness in discovering the presence of an item or group of items. Ceramic chronologies, for example, often rely merely on the presence of a certain type or complex of types in an assemblage for determining which ceramic period(s) the assemblage belongs to (seriation analyses are an exception to this). Similarly, functional analyses of site contents often require only that a certain tool type (single item) be present in order to conclude that the associated activity (e.g., grinding for ground stone) took place at the site. In multiple item discovery, multiple artifact or feature types are detected when present, allowing for interpretations based on association. Individual item discovery, on the other hand, does not allow for analyses of association.

The most important characteristic of the Phase I TRU system, as a sampling design for discovering various classes of cultural remains, is that the TRUs comprise a systematic sample of a regular grid system imposed on the underlying distribution (in this case, the landscape or a part thereof is the "assemblage"). The grid system being sampled consisted of the 15,000 possible TRUs in each square kilometer (of which 900 were actually recorded—a 6 percent sample). Obviously, the probability that a given item class (or classes) will be discovered by the sample (i.e., encountered at least once) is proportional both to how common it is and to the sampling fraction (i.e., the number of grids sampled).

Nance (1981:155) cites Johnson and Kotz (1969:157) as stating that the number of grids or the sample size (n) needed to discover an item class is given by the negative hypergeometric distribution and is a function of the relative abundance of the item (i.e., the number [k], of all possible grids [N] in which it occurs). This is equivalent to absolute ubiquity as defined above in the section on the nature of the archeological landscape ($U_{,T} = k/N$). The expected value of this function, that is, the average N required for discovery of one item, is:

$$E[n] = \frac{N}{k+1}$$

The variance associated with this value is calculated as follows:

$$\mathrm{var}[n] = \frac{k(N+1)(N-k)}{(k+2)(k+1)^2}$$

The variance is severely inflated by small values of k, that is, when the target item occurs rarely, because E[n] is proportional to N and inversely proportional to k. This means that with smaller values of k, the required n for discovery is often significantly larger than E[n].

Another way to look at discovery sampling is to model it as a binomial probability distribution (Blalock 1979:151). In this case, the absolute ubiquity of the item (k/N) at a given grid size becomes the expected proportion (p), the number of grids sampled becomes the sample size (n), and 1 (or more) becomes the x for which the probability is calculated. Since the binomial is a discrete distribution, to compute the discovery probability P of item class k, in a sample of n grids with a ubiquity of p, we compute the probability of *not* getting a result of zero (here P_h stands for the standard binomial probability function (SAS Institute 1982a:178):

$$P = 1 - P_h(p,n,0)$$

This formula yields the probability of *not* getting a result of zero and thus the probability of encountering one or more target items. To obtain the probability of discovering more than one item class we simply take the product of their individual probabilities (the multiplication rule) (Blalock 1979:124).

It is important to remember that the binomial probability method is not particularly sensitive to absolute abundance or spatial aggregation. If an item tends to occur in clusters, then its ubiquity and its expected proportion are decreased along with the resulting probability estimate. One example using TRUs as grids is that if hammerstones occur 100 times/sq km and are evenly distributed, they have a ubiquity of 100/15,000 or 0.0067; if they cluster in piles of 10, however, they have a ubiquity of 10/15,000 or 0.00067. The variable of count/sq km is a convenient measure of effective ubiquity. The resulting discovery probabilities for the 6 percent TRU sample at a resolution of 900 TRUs/sq km are 0.998 and 0.451, respectively. In other words, an item class with a ubiquity of 0.00067 has roughly a one in two chance of being discovered. Thus, discovery probabilities are a function of absolute ubiquity and not overall density.

Table 6.1 shows the theoretical relationship between ubiquity and one- and five-item discovery probabilities for grouped TRU sample sizes ranging from 9 to 900 TRU grids (i.e., TRUs grouped into grids 100–1000 m on a side). Perfect visibility in TRU sampling is assumed. The five-item discovery probabilities assume equal ubiquities for the five artifact classes and represent the one-item probabilities raised to the fifth power (i.e., the product of the five individual probabilities). Similarly, the probabilities for joint discovery of 10 classes can be calculated by raising the one-item probabilities to the tenth power (a ten-item probability of 0.95 requires a one-item probability of 0.995).

The figures in Table 6.1 can be used to determine theoretically expected confidence levels and the effective resolution of the TRU discovery sample at various scales. For

Table 6.1. **One- and five-item discovery probabilities vs ubiquity for TRU sampling at the following grid sizes: 100, 200, 500, 800, 1000 m**

Ubiquity	Count per sq km	One-Item Probabilities 100	200	500	800	1 km	Five-Item Probabilities 100	200	500	800	1 km
0.0002	3	0.002	0.007	0.044	0.109	0.165	0.000	0.000	0.000	0.000	0.000
0.0005	8	0.004	0.018	0.106	0.250	0.362	0.000	0.000	0.000	0.001	0.006
0.0010	15	0.009	0.035	0.202	0.438	0.594	0.000	0.000	0.000	0.016	0.074
0.0030	45	0.027	0.103	0.491	0.823	0.933	0.000	0.000	0.029	0.377	0.707
0.0050	75	0.044	0.165	0.676	0.944	0.989	0.000	0.000	0.141	0.751	0.946
0.0070	105	0.061	0.223	0.794	0.983	0.998	0.000	0.001	0.316	0.916	0.991
0.0090	135	0.078	0.278	0.869	0.995	1	0.000	0.002	0.496	0.973	0.999
0.0100	150	0.086	0.304	0.896	0.997	1	0.000	0.003	0.577	0.985	0.999
0.0200	300	0.166	0.517	0.989	1	1	0.000	0.037	0.948	1	1
0.0300	450	0.240	0.666	0.999	1	1	0.001	0.131	0.995	1	1
0.0400	600	0.307	0.770	1	1	1	0.003	0.271	0.999	1	1
0.0500	750	0.370	0.842	1	1	1	0.007	0.424	1	1	1
0.0600	900	0.427	0.892	1	1	1	0.014	0.565	1	1	1
0.0700	1050	0.480	0.927	1	1	1	0.025	0.683	1	1	1
0.0800	1200	0.528	0.950	1	1	1	0.041	0.775	1	1	1
0.0900	1350	0.572	0.966	1	1	1	0.061	0.843	1	1	1
0.1000	1500	0.613	0.977	1	1	1	0.086	0.892	1	1	1
0.1500	2250	0.768	0.997	1	1	1	0.268	0.986	1	1	1
0.2000	3000	0.866	1	1	1	1	0.486	0.998	1	1	1
0.2500	3750	0.925	1	1	1	1	0.677	1	1	1	1
0.3000	4500	0.960	1	1	1	1	0.814	1	1	1	1
0.3500	5250	0.979	1	1	1	1	0.901	1	1	1	1
0.4000	6000	0.990	1	1	1	1	0.951	1	1	1	1
0.4500	6750	0.995	1	1	1	1	0.977	1	1	1	1
0.5000	7500	0.998	1	1	1	1	0.990	1	1	1	1

example, at a resolution of 1 km the individual discovery probability exceeds 0.95 at a level of $U \geqslant 0.004$, while for the multiple discovery of five items, the probability exceeds 0.95 at a level or $U \geqslant 0.005$. Table 6.1 can thus be used to determine 95 percent confidence thresholds, in terms of ubiquity, for one- and five-item discovery for scales from 100 m to 1 km. Table 6.2 presents 95 percent ubiquity thresholds for grouped TRU grid sizes ranging from 100 m to 1 km (ten-item discovery probabilities are based on a one-item threshold of 0.995; see above).

These figures can be compared with known ubiquity figures calculated from Phase II data. Table 6.3 presents TRU-level ubiquity data for 10 lithic artifact classes from the six Phase II units surveyed. Most important are the mean ubiquity figures for Units 1, 2, 5, and 6, which represent the most common landscape types—and those with the lowest density of cultural remains, for the most part—in the Border Star 85 area. All the classes listed exhibit ubiquities of 0.02 or greater and at 1 km they far exceed the 95 percent confidence threshold of 0.005 (as expected, ubiquities for Units 3 and 4 are even higher). In fact, Table 6.1 indicates that the five-item discovery probability for 1 km samples with a ubiquity of 0.02 is 1. Since 1^{10} is also 1, it is expected that the presence of most or all major lithic tool classes was adequately documented at the 1 km level by the 6 percent TRU sample in the Border Star 85 survey, even in terms of joint discovery of 10 classes.

Table 6.2. Theoretical 95 percent confidence discovery thresholds for one-, five-, and ten-item discovery

Grid Size	100 m	200 m	500 m	800 m	1 km
One-Item	0.290	0.080	0.014	0.005	0.004
Five-Item	0.400	0.041	0.020	0.008	0.005
Ten-Item	0.450	0.105	0.026	0.009	0.006

The figures in Table 6.2 can also be used to determine the theoretically expected effective resolution of the various grid sizes for ubiquities $\geqslant 0.02$ for one-, five-, and ten-item discovery. Essentially, the effective resolution for ten-item discovery is 800 m, that for five-item discovery is 500 m, and the effective resolution for one-item discovery lies between 200 and 500 m.

The ubiquities of chronological markers are probably considerably lower. For example, ceramics tend to exhibit aggregation more than other artifact classes, resulting in reduced ubiquity and lower discovery sampling probabilities. Phase II ceramic ubiquities range from between 0.01 and 0.02 for Units 2 and 5 to 0.07 for Unit 6 and 0.30 for Unit 3, suggesting that the TRU data adequately record the presence of ceramics at the same levels as most lithic types. Generic ceramics may be rather abundant; however, types diagnostic of particular ceramic periods are considerably more rare.

Table 6.3. TRU-level ubiquity statistics for Phase II lithics by unit (units grouped by cluster type)

Cluster Type	Unit	Angular Debris	Flake	Thinning Flakes	Cores	Pounding Tools	Informal Tools	Point/ Bifaces	Unifaces	Manos	Metates
(1)	1	0.03556	0.12444	0.00000	0.03111	0.02222	0.00444	0.00889	0.00444	0.03111	0.07111
	5	0.03111	0.11556	0.00444	0.04000	0.01333	0.00889	0.01778	0.00889	0.03556	0.08889
(3)	2	0.14667	0.32889	0.07111	0.04000	0.02222	0.04000	0.01778	0.03111	0.05778	0.09778
	6	0.07111	0.15111	0.03111	0.04889	0.03111	0.01778	0.00889	0.01778	0.02222	0.04000
Mean*:		0.07	0.18	0.03	0.04	0.02	0.02	0.05	0.02	0.04	0.07
(8)	3	0.2667	0.42222	0.15111	0.19111	0.05778	0.08889	0.09778	0.08000	0.12889	0.12444
(18)	4	1.0	1.0	0.44444	1.0	0.88889	0.44444	0.33333	0.22222	0.66667	0.66667

*Units 1, 2, 5, and 6

Temporally diagnostic ceramics (other than brownwares) were found in only two Phase II units, Units 3 and 4. Not surprisingly, the TRU-level ubiquity for diagnostic ceramics in Unit 4 is one. The figure for Unit 3 is 0.11. For Unit 6, which also contained ceramics, the figure is effectively zero since no diagnostics were found. Thus, the TRU system can be expected adequately to have discovered diagnostic ceramics in the higher density areas where diagnostic types are more common. In low density areas, however, diagnostic types were probably not discovered with any reliability, simply as a function of their rareness.

Time-diagnostic projectile points are, if anything, even less ubiquitous than diagnostic ceramic types. Identifiable projectile points occurred in only 261 of the more than 200,000 TRUs inspected in Phase I. Using this as an estimate of projectile point ubiquity yields a figure of 0.0013. Multiplying by three (the approximate overall degree of underestimation in the TRU data) results in an estimated actual ubiquity of 0.004. The one-item figures in Table 6.2 suggest a 95 percent discovery confidence for projectile points in general at the 1 km level; the ubiquity figures for more specific point types (e.g., types diagnostic of major occupational periods) are presumably somewhat lower due to the fact that they are less common than all points combined. Thus, although we can be 95 percent confident that the presence of points per se was adequately discovered at the 1 km level, the effective resolution of the TRU data for documenting specific prehistoric periods on the basis of projectile points must be greater than 1 km.

In general, the effective resolution of the TRU data for discovering temporally significant information may be fairly poor, thus requiring larger grid sizes than those sufficient for detecting the presence of various lithic artifact classes. As noted in Chapter 5, however, the use of large units on the order of a kilometer in size, precludes most traditional approaches to assemblage analysis. The nature of the TRU data leads thus to an unfortunate paradox: for purposes of chronological analysis, we are forced to group the data into such large units that to use a single Early Archaic point, for example, to designate a square kilometer as "Early Archaic" is ridiculous. Such an approach would also lead undoubtedly to a multicomponent designation for most units; many could only be termed "Holocene in age"! Given this problem, it hardly makes sense to perform conventional functional analyses of the contents of multicomponent assemblages.

Site Discovery Probabilities

One question to be addressed specifically in the Border Star 85 project is referred to in the original solicitation as the "small sites problem." This problem originally referred to questions concerning the ability of the TRU system to discover small sites; however, it is clear that serious questions also exist regarding sampling the content of small sites. The results presented in Chapter 5 in the section on Phase II unit selection leave little doubt that the TRU system not only failed to detect some sites but that assemblage sampling fractions are frequently unacceptably low. Although no calibration of site content estimation was performed, it seems highly probable that the problems are most severe with respect to small sites. Since by far the majority of sites recorded in the Border Star 85 survey fall in the small size category, the magnitude of this problem is considerable.

Table 6.4 shows the breakdown of Phase I sites by size classes defined in terms of the number of occupied TRUs. Estimated site diameter equivalents are included and represent the square root of the TRU counts multiplied by a TRU "diameter" of 33.3 m. Fully two-thirds of the sites in the Border Star 85 area fall in the one-TRU category and

Table 6.4. Number of TRUs per site and equivalent site diameters for Phase I sites

TRUs/ Site	Diameter m	Total Area	Total Sites	Percent	Cumulative Percent
1	33	1870	1178	65.517	65.517
2	47	1750	309	17.186	82.703
3–4	55–70	2600–3500	167	9.288	91.991
5–9	75–100	4360–7850	87	4.839	96.830
10–20	100–150	8–17K*	39	2.169	98.999
21–37	150–200	18–32K	6	0.334	99.333
37–225	200–500	33–196K	11	0.612	99.944
225+	500+	196K+	1	0.056	100.000

*K = 1000 sq m

represent very small sites with the potential to be undiscovered by the TRU grid system. Roughly 82 percent of the site locations occupy only one or two TRUs.

The probability of discovering a circular site of diameter S using point or transect sampling at interval I is essentially S/I. Multiplying this value by 100 yields the expected percentage of sites of that size which will be found (Krakker et al. 1983:471). It follows that all sites with S≥I will be found, and that the discovery rate for small sites (S<33 m) on the Border Star 85 survey should be inversely proportional to their size. Table 6.5 shows the theoretically expected small sites discovery rates for sites less than 33 m in diameter.

As the results of the Phase II survey indicate (Chapter 7), many sites are smaller than 30 m, and many sites were missed by the TRU survey. Krakker et al. (1983:477:479) have pointed out that artifact density variations and aggregation at sites can reduce the effective diameter of sites by reducing their visibility. Since small site artifact densities are often low, the expected discovery rates shown in Table 6.5 should probably be adjusted downward.

Estimating the number of small sites missed from these figures would be a complex function of the actual distribution of site sizes and densities. Given the above discussion, however, the low-site discovery rates in Table 6.5 for all but Unit 4 (25–30 percent, or 70–75 percent missed) are hardly surprising. Thus, it seems quite possible that more than 50 percent of the small sites in the Border Star 85 area were missed.

Sampling for Proportional Estimates

One of the most common analytical techniques used by archeologists is that of comparing artifact assemblages in terms of their proportional content for the purposes of making behavioral interpetations (Doleman 1985). For example, if one assemblage contained 60 percent scrapers while another contained only 5 percent, the archeologist might conclude that scraping activities were considerably less important in the latter than in the former. Normally, it is assumed that both assemblages represent adequately sampled populations, but in the case of the Phase I TRU data, we must ask how the spatial characteristics (aggregation) of the target population (the archeological surface distribution) affect the reliability of the sampling design in estimating proportions.

Mathematically, a proportional estimate ($\hat{p}$) from a cluster sample (also called a cluster sample estimate or CSE) is defined as:

$$\hat{p} = x/n$$

where x is the number of target items and n is the total number of items in the sample. Nance (1981:161); states that the variance of a proportional estimate from a cluster sample (var[$\hat{p}$]) is approximated by:

$$\text{CSE Var}\,[\hat{p}] = 1 - \frac{F}{N} \cdot \sum_{i=1}^{N} \left(\frac{M_i^2}{M}\right) \cdot \left(\frac{(p_i - \hat{p})^2}{(N-1)}\right)$$

where F is the sampling fraction, N is the number of clusters in the sample, $\hat{p}$ is the estimate, M is the mean cluster size, M_i are the individual cluster sizes, and p_i are the individual estimates.

The result is "the weighted [by cluster size] mean of individual cluster-sample variations around $\hat{p}$" (Nance 1981:161), which becomes larger in proportion to cluster-to-cluster variability in both cluster size (M) and individual proportional estimates (p_i). Variability in p_i is most affected by "intra-cluster homogeneity," which is defined as a tendency for clusters to contain only one class of remains. This homogeneity results in turn from the differential aggregation of artifact types in space (e.g., thinning flakes in some places vs primary ones in others) and is a common, albeit often expected, attribute of spatial configurations of archeological data. Cluster size variation (M_i), on the other hand, is generally caused by overall spatial aggregation of artifacts without regard to type.

In element or simple random samples [SRS], which are the model for cluster sample cases, the variance of a proportional estimate is:

$$\text{SRS var}(p) = p\,\frac{(1-\hat{p})}{(n-1)}$$

Where p is the estimate and n is the number of elements in the sample. In any given case, the effect of cluster sampling on the variance of the estimate is reflected in the ratio of the CSE and SRS variances (also called the design effect or DEFF). This ratio is in turn a measure of the degree to which the SRS variance underestimates the true variance. Finally, the total number of items or elements recovered (the cluster sample size) can be adjusted by dividing by the square root of DEFF to yield "an element sample size of comparable precision," also called the effective sample size or ESS (Nance 1981:162). Simply put, in cluster sampling the ESS and the precision of proportional estimates are inversely related to DEFF and thus to both overall and differential (item class-related) aggregation. Consequently, the considerable aggregation evident in the Border Star 85 archeological landscape can be expected to reduce significantly the precision of proportional estimates of assemblage content for grid units of various sizes.

Nance (1981:162–164) also notes that ESS is inversely

Table 6.5. Theoretical small site discovery rates

Site Diameter (m)	Area (sq m)	Discovery Rate (%)
30	707	90.0
25	491	75.0
20	314	60.0
15	177	45.0
10	79	30.0
5	20	15.0

proportional to mean cluster size and, as a result, to overall density. Thus, increasing the cluster size by using larger individual sample grids can reduce precision. As a result, optimal cluster sampling designs incorporate "as large a number of small units as possible" (Nance 1981:165). The latter approach has the effect of increasing N, reducing the CSE var[p̂] estimate and thus the DEFF, and increasing the absolute number of elements included in the sample. With respect to the TRU data this translates into increasing both N (the number of TRUs in a sample) and the total number of elements sampled by grouping TRUs into grids or blocks of lesser spatial resolution. Larger block sizes should reduce the variance in both cluster size and the individual proportional estimates. In other words, in order to increase the precision of proportional estimates from the TRU data, it is necessary to group them into large grids.

From a theoretical perspective, several conclusions concerning the reliability of the Phase I data have been drawn:

1) In order to achieve sample reliability in the areas of both discovery and statistical precision, the Phase I TRU data must be grouped into larger units.
2) The effective resolution of the Phase I data for discovery of different artifact classes varies depending on abundance and ubiquity. Most or all artifact classes were probably adequately discovered at the 800–1000 m scale. Single classes of lithic artifacts have a better effective resolution: 200–500 m. Rare items such as chronologically diagnostic ceramics and projectile points require 1000 m or greater resolution for effective sampling.
3) The transect survey probably missed 50 percent or more of the small sites (less than 30 m diameter) in the survey area. Since the overwhelming number of sites in the area is small, a considerable quantity of cultural remains is undoubtedly absent from the Phase I record.
4) Due to both the nature of cluster sampling and to aggregation in the target material, the precision of the Phase I data is poor. Such a lack of precision affects the estimation of actual numbers of items as well as the development of proportional estimates.

Empirical Calibration

The calibration selected for treatment in this analysis centered upon artifact counts in which Phase I artifact total estimates were compared with the actual counts revealed by the Phase II survey. Only one count variable was calibrated: overall lithic counts (including chipped and ground stone tools and debitage). Lithics were chosen as the basic calibration variable since they represent the most ubiquitous item on the Border Star 85 landscape and have considerable analytical importance in terms of behavioral interpretations.

At the outset of the calibration of counts it was expected that increasing grid size, and thus increasing the number of TRUs in a grid sample, would have the effect of increasing the *accuracy* of the data in each pixel of the resulting landscape image. It was expected that the discrepancy between the Phase I estimate and the Phase II reality would decline with increasing grid size. The method used in the calibration involved a comparison of the Phase I count estimates with those from Phase II and an evaluation of the null hypothesis that there was no significant difference between the two. It was anticipated that the threshold of effective resolution would be achieved at a grid size for which the hypothesis could not be rejected. It was at this point in the analysis that the importance of discriminating between accuracy and precision in calibrating the TRU data was realized.

Following this, several suggested measures of the variance of the estimate and the variance of the error were developed for the purpose of diagnosing variations in precision and were evaluated at various grid sizes. As expected, the overall variance declined with increasing grid size. The simple conclusions were, first, that the TRU data were inaccurate by a factor of 3 (minus 67 percent), and second, that the variance of the estimate appeared to stabilize somewhere between 267 m (8 by 8 TRU grids) and 500 m (15 by 15 TRU grids).

Ideally, determining the accuracy and precision of a random sampling design involves applying the design to the same known population as many times as possible. The mean of the resulting parameter estimates (usually the mean of the individual sample means) is compared with the population parameter (e.g., mean) to determine the accuracy or amount of bias in the design (in other words the average error). The variance of the individual sample means is viewed as a relative measure of precision (or consistency) and is usually evaluated by comparing the variances of two or more sampling distributions or designs (the multiple applications of the design to the known population constitute an estimate of the sampling distribution).

Such a procedure is obviously not possible with the TRU data since it would involve instituting the TRU methodology multiple times on the same landscape. In the case of the Border Star 85 project, it is necessary to view the Phase I TRU data from the six Phase II units as if they were a single sample run performed on the known Phase II population. An analogue for multiple sample runs is provided by the individual cluster samples produced by grouping the TRUs from a given Phase II unit into grids, for example, grids that are 3 TRUs (100 m) on a side. In this case, a 500 m Phase II unit would contain 25 3 by 3 TRU grids or "sample runs," each containing a total of 9 TRUs. In this analogy, the sampled populations are the Phase II data from the areas corresponding to the TRUs in each grid, and each multiple TRU grid in a Phase II unit represents a separate sample run on a portion of the unit.

The problem with the preceding method is that, since each grid represents a different part of the Phase II unit under consideration, each sample run (i.e., grid or TRU block) is from a different population. Under these conditions, the variance of the estimate (precision) is actually the variance among the individual Phase I TRU counts from each grid (i.e., from the 9 TRUs in a 3 by 3 TRU grid). Similarly, the estimate itself (in this case the estimate of the population total) is the total of the counts, and the difference between the Phase I and II totals is a measure of accuracy or bias for that grid.

Using this approach, accuracy and precision are estimated

by evaluating the average success of a single sample run applied to multiple populations, or to portions of a larger one (a Phase II unit). As a result, accuracy can only be estimated by the average difference (or error) between the Phase I and Phase II counts, while precision is measured by the average of the individual grid variances.

In order to compute measures reflecting the accuracy and precision of the Phase I sample, the Phase II data were summarized by associated TRUs. The process involved rounding the 2 by 2 m grid coordinate values (0–498) to the nearest 33.3 m and converting the resulting values to the corresponding TRU coordinates (0–29). During the Phase II fieldwork, care was taken to ensure that the 2 by 2 m grid coordinate system was accurately registered with respect to the original TRU system. Comparison of the Phase II 1:750 aerial imagery with the 1:3000 imagery indicates that the maximum registration error is on the order of 2–5 m, a value that is acceptably small in comparison with the TRU resolution of 33.3 m.

In order to make maximum use of the Phase II data, several problems had to be overcome. As grid sizes increase, the number of TRUs in each grid (the sample N) increases while the the number of grids in each unit (the number of sample runs) decreases. In addition, the degree to which the grids fit neatly into the 500 m space of a unit varies with the grid sizes. For example, when the grid size is 4 TRUs (133.3 m) on a side, only three complete grids fit across a 500 m Phase II unit. Poor fits of this sort result in strips of unincorporated Phase II data on the edges of the unit. The location of these strips is a function of how the grid system of that size is registered with respect to the unit. In the 4 by 4 TRU grid size above, four registrations are possible: the block of 12 by 12 TRUs in the SW corner of the Phase II unit, along with the SE, NE, and NW blocks. In addition, at grid sizes of 8 or more TRUs (267 m) on a side (i.e., greater than 0.5 km), only one grid per unit is possible, resulting in a unit/grid sample size of one and in very large strips of unused Phase II data. Finally, the arbitrary nature of grid systems ensures that some variability in various grid statistics will also be a function of registration.

The solution to these related problems was to make multiple computation runs, each with a different registration, at each grid size. The maximum number of runs was three, and the different registrations were positioned as far apart as possible. For example, when three runs were made, the three registrations were at the southwest corner, in the center, and at the northeast corner. In this method, the advantages of including more of the Phase II data and of varying the registration are thought to outweigh the possible statistical disadvantage of using some of the data more than once.

Lithic counts from both phases were then used to compute a number of statistics for each grid in each Phase II unit for grid sizes ranging from 1 to 14 TRUs on a side, representing resolutions ranging from 33.3 to 467 m. In addition, the adjacent Units 2 and 5 were combined to simulate a single square unit measuring 21 TRUs on a side; Units 1, 2, 5, and 6 were combined to simulate a 1.0 sq km unit of 29 TRUs on a side. Data from Unit 4 were treated separately because the unit measures only 100 m across (3 TRUs) and greater grid sizes were obviously impossible.

A considerable variety of statistics was computed by grid for each multiple TRU grid in a Phase II unit and analyzed for heuristic purposes. The most important ones include the following:

1) *The Phase I estimate:* The total Phase I count (adjusted for the TRU sampling fraction of 6 percent), which corresponds to the estimate for the grid.
2) *The Phase II count:* The actual number of lithics present, that is, the true population value.
3) *The Phase I s:* The standard deviation of the Phase I TRU counts. This figure represents the square root of the variance of the estimate for each grid.
4) *The Phase II s:* The standard deviation of the Phase II counts or the population variance for each grid.
5) *The TRU error:* The mean absolute difference between the Phase I and II TRU counts. This is the mean error of the estimate.
6) *The TRU s:* The standard deviation of the TRU error or the standard deviation of the error.
7) *The Grid error:* The difference between the Phase I and II grid totals expressed as a percent of the Phase II grid total. This value is negative in cases where the Phase I grid total is less than the Phase II count (underestimation) and positive in cases of overestimation. The grid error is the actual "error of the estimate" for a given grid and is an estimate of the sampling bias.
8) *The Phase I/II s* ratio: The ratio of the Phase I and II count standard deviations (2 and 3, above). The result is the square root of the true variance ratio.
9) *Phase I "zero" TRUs:* The proportion of occupied Phase II TRUs for which no Phase I data were recorded.
10) A one-tailed *t*-test statistic that compares the Phase I TRU counts with their Phase II counterparts.
11) A one-tailed Wilcoxon matched-pairs, signed-ranks test that compares the Phase I and II TRU counts.

The first two variables form the basis for calculating the others. Standard deviations were used as simple square root transformations of the variances, because the scale of the variances was so large that they generally required just such transformation prior to plotting. Since it is based on TRU counts, the mean TRU error represents the artifact density estimate error and is expressed in units of density/TRU. Converting the grid error to a percentage corrects for increasing grid size since the actual count differences are correlated with grid size.

As noted earlier in this chapter, the goal of the calibration was to discover the grid size (effective resolution) at which Phase I count estimates became consistent or, in sampling terms, precise. It was expected that increasing TRU grid size would result in declining variances (or *s*) among the Phase I count estimates and thus in increasing precision. In addition, the error or bias measures should stabilize as precision increases. Thus, the accuracy—or more properly, an accurate estimate of the bias in the design—should be reflected in the stabilized error or bias.

Given the problems with simulating multiple runs described above, one way to evaluate the variance of the estimate is to compare it with the population variance. As

precision increases and the variance of the estimate declines, the ratio of the two (or the ratio of the *s*) should approach one or a value reflecting the true bias. Since the variance of the estimate is expected to be generally larger than the population variance, the Phase I/II *s* ratio is expected to decline as a function of increasing precision.

Two significance tests were used to measure accuracy: the *t*-test, and the Wilcoxon matched-pairs, signed-ranks test. As noted, the original intent was to use them to diagnose the level of resolution at which no significant difference existed between the estimate and the population value.

A *t*-test (Blalock 1979:190) was used to determine the difference between the mean Phase I and Phase II TRU counts for each grid. Although the *t*-test results are less robust than those provided by the Wilcoxon test, they are included because the *t*-test allows for smaller sample sizes (as small as 2) than the nonparametric test. Sample sizes were often small because truly empty TRUs were excluded from the calculations to avoid the "false accuracy" involved in correctly detecting nothing.

The Wilcoxon matched-pairs, signed-ranks test is a nonparametric test used to compare the values of a continuous variable for a set of paired observations; it tests whether the values tend to differ under the "treatments" represented by the two samples (Siegel 1956:75). The Wilcoxon test offers the advantage of not assuming normally distributed counts, which—because of aggregation—are rare in the TRU data. Both tests used are legitimately one-tailed tests since the directionality of difference is predicted (i.e., it was anticipated that the Phase I estimates would be less than the Phase II population counts).

Table 6.6 shows the *t*-test results as the percentage of grids with significant differences between mean Phase I and Phase II lithic counts for each unit and for all Phase II units combined (excluding Unit 4). Table 6.7 shows similar percentages for the Wilcoxon test results. Grid sizes in these tables, and in all the following tables and figures, are expressed in terms of TRUs on a side. Thus, a two-TRU grid contains four TRUs and is 67 m on a side, a nine-TRU grid contains 81 TRUs and is 300 m on a side, and so forth. Percentages for 21 and 29 TRU grids are from the 0.5 and 1 square kilometer grids simulated by combining Units 2 and 5, and by combining Units 1, 2, 5, and 6, respectively. A rather lax alpha (significance probability level) of 0.10 was used in order to help reveal trends. An investigation of the individual results showed that, especially in the case of the *t*-tests, nonsignificant differences reflect grids in which one TRU hit a "hot spot" and grossly overestimated the density, thus balancing out the rest of the TRU underestimates.

Both tables clearly show that the proportion of grids with significantly different lithic counts increases with grid size until all grids are different. This evidence reflects the bias in the TRU system and is proof of the overall tendency of the TRU data to underestimate landscape content. The pattern is strongest for the Wilcoxon tests, which, given the distinctly non-normal distributions involved, are presumably more robust indicators than the *t*-tests. Only Unit 5 fails to conform completely to the pattern in that none of the *t*-tests for grid sizes of 13 and 14 TRUs is significant. The Wilcoxon tests are significant for both grid sizes. Nonetheless, inspection of the actual counts for Unit 5 at grid sizes of 13 and 14 reveals little difference between the Phase I and II counts and even shows one case in which the Phase I count exceeds that of Phase II (grid errors for the cases in question range from −34 to +11 percent). It seems possible that this situation is a combined function of the registration and the dispersed nature of the artifacts in Unit 5.

Owing to the comparatively small size of Unit 4, most of the calibration analyses performed on the data from the other units were not feasible for this unit. It was possible,

Table 6.6. Lithic counts calibration: *T*-test results: Percentage of significantly different grids*

Grid Size (in TRUs)	Units					
	1	2	3	5	6	All
2	25	38	32	36	8	30
3	57	64	57	56	22	53
4	89	88	56	62	46	67
5	100	73	67	40	38	61
6	80	75	50	38	50	57
7	80	88	50	25	50	57
8	67	100	67	33	67	67
9	67	67	100	33	33	60
10	67	67	67	33	33	53
11	67	100	67	33	33	60
12	100	100	100	50	50	80
13	100	100	100	0	50	70
14	100	100	100	0	100	80
21						100
29						100

*p≤.10

Table 6.7. Lithic counts calibration: Wilcoxon test results: Percentage of significantly different grids*

Grid Size (in TRUs)	Units 1	2	3	5	6	All
2						
3		57	43	100		56
4	83	92	71	100	67	82
5	100	89	80	60	50	79
6	83	100	100	50	33	74
7	86	100	100	86	67	89
8	100	100	100	100	100	100
9	100	100	100	100	33	87
10	100	100	100	100	67	93
11	100	100	100	100	100	100
12	100	100	100	100	100	100
13	100	100	100	100	100	100
14	100	100	100	100	100	100
21						100
29						100

*p≤.10

however, to compute some of the relevant statistics for the one 3 by 3 TRU grid from Unit 4. Table 6.8 presents the results of the Unit 4 analyses for six artifact classes of varying abundance: lithics, ceramics, tools, time-diagnostic ceramics, ground stone, and cores. The relative frequencies of the different classes are evident in the Phase I and Phase II counts. Also included are the results of the *t*- and Wilcoxon tests, the percent of negative differences (i.e., Phase I underestimated TRUs), the mean count difference per TRU and the standard deviation of this mean, the grid error percent (see above), the Phase I and II TRU count standard deviations, and the ratio of these last two figures (the variance ratio). The results for overall ceramics have been excluded due to a computational error that was discovered too late to allow recalculation.

The results of the significance tests are revealing although somewhat inconclusive. The question marks for the Wilcoxon test indicate that p is > 0.025 with no upper boundary and thus the difference may be significant. With the exception of ceramics, the *t*-tests clearly indicate no significant difference, which suggests that, for many kinds of counts data, the TRU system is successful when artifact densities are as high as they are at this particular site.

Although no statistical tests were run on the overall ceramic counts, the Phase I estimate differs from the Phase II figure by less than 3 percent, indicating that the Phase I data are quite accurate.

The *s* ratios for the other classes presumably reflect variations in the structure of the underlying distributions, with higher ratios indicating increased aggregation or the effects of rareness. This expected relationship is a function of the effects of aggregation on the variance of the Phase I estimate. Thus, the most common items—lithics—have the lowest ratio, while the relatively rare diagnostic ceramics (these may have been somwhat affected by the same error in computation, but not nearly as severely) exhibit the highest ratio. The low ratio for cores indicates relative ubiquity. The grid error figures also reflect this relationship between aggregation and *s* ratios in that the three highest ratios are associated with positive (overestimation) grid errors. As noted above, overestimation generally results from TRUs hitting high-density loci. In this case, the loci result from small-scale aggregation on the site.

These data suggest several important points. First, the transect data appear to exhibit better overall accuracy in

Table 6.8. Unit 4 counts calibration: *t*-test and Wilcoxon test results

Artifact Class	Signif *t*	Signif W	Phase I Count	Phase II Count	% Neg Diff	Mean Diff	*s* Diff	Grid Err	Phase I TRU *s*	Phase II TRU *s*	Phase I/II *s* Ratio
Lithics	No	?	1017	1728	77.8	−29	302	−15.1	283.3	122.7	2.3
Ceramics	—	—	3633	3730	—	—	—	—	—	—	—
All Tools	No	?	200	159	55.6	4.6	23	+25.8	23.6	7.3	3.2
Diagnostic Ceramics	No	?	167	117	66.7	5.5	35	+42.7	33.8	5.4	6.3
Gr. Stone	No	?	84	51	55.6	3.6	13	+64.7	12.1	2.6	4.7
Cores	No	?	33	78	88.9	−5	13	−57.7	11.1	4.8	2.3

Notes: "?" for Wilcoxon test indicates unknown p>0.025; difference is possibly significant. Test not run for overall ceramics (see text).

the one dense site calibrated. Second, the degree of success is conditioned by the amount of on-site aggregation. The Unit 4 data suggest that the level of site aggregation may result in overestimation of even low-abundance artifact classes. Finally, as might be expected, the relationship between s ratios and aggregation suggests that the system is less precise for aggregated materials, even in high-density site contexts.

It should also be noted that the lithic counts s ratio for Unit 4 (2.3) is generally larger than the mean ratios from the other units of the 3 by 3 TRU grid size, which range from 0.5 (Unit 3) to 3.1 (Unit 6) (see below). Because the units are so different in nature and size, this distinction is difficult to interpret. It probably reflects the combined effects of higher overall counts and site-level aggregation on the resulting statistic; that is, in high-density landscapes, the discrepancies among the variances (or s) are exacerbated by the generally higher TRU counts. The low ratios for the high-density Unit 3 are not in keeping with this conclusion, however, and it is probable that the principal cause for the high ratios in Unit 4 is small-scale aggregation.

Table 6.9 presents summary statistics by grid size (TRUs/side) for the variables described above for Units 1 and 5 (Cluster 1), Units 2 and 6 (Cluster 3), Unit 3 (Cluster 8), and all units combined (including Unit 3). With the exception of the standard deviation of the grid error, all figures are means for the individual grid statistics. Thus, the figures represent the averages by unit of the various statistics.

One of the most interesting statistics is the proportion of empty Phase I TRUs. There is, of course, no particular relationship between the mean value of emptiness and grid size, since there is no expected correlation between the rate at which TRUs miss data and the number of TRUs grouped in a grid. What is interesting is the fact that rarely is the average proportion less than 0.90. So that one may conclude that on the average, over 90 percent of the occupied space went undetected in the Phase I survey!

For the most part, aggregation can account for this high percentage of undetected area. Under conditions of total aggregation, in which artifacts occur in dimensionless piles, only 6 percent of the piles are encountered by the TRU system, and some 94 percent go undetected (assuming the piles are randomly distributed). The latter figure differs little from the 91–93 percent implied by the empty Phase I TRU proportions for all units combined, suggesting that the TRU data in general conform to an aggregation model in which the clusters or aggregates are numerous and small (i.e., nearly dimensionless). In confirmation of this it is useful to note that the zero TRU proportions for Unit 3, which exhibits less overall aggregation, are lower (0.81–0.90) than those of the other units.

The implications for the goal of documenting landscape content are serious: if only 6 percent of the concentrations of artifacts and features are documented, then only 6 percent will contribute to the overall estimate. If there is considerable variability in content among these concentrations, then the resulting proportional estimates will be a random function of the piles encountered. This is a practical form of the problem of intracluster homogeneity (Cochran 1977). As Nance (1981) has noted, intracluster homogeneity is an expected and even desirable aspect of spatially distributed assemblages. The lesson is that, while density estimates may be reliable at a certain resolution, the reliability of proportional estimates may be somewhat less. A corollary is that the simple calibration of counts data may not be entirely sufficient, as was originally hoped.

Three trends are evident in the other data in Table 6.9.

1) Variables whose means tend to stay the same: grid error, mean TRU density error (except Unit 2), and empty Phase I TRUs.
2) Variables whose means increase: s of mean TRU density error, Phase I s, and Phase II s.
3) Variables whose means decline: s grid error and Phase I/II s ratio.

Those variables whose means exhibit little change are not sensitive to grid size and therefore are measures of ac-

Table 6.9. Lithic counts calibration: Means for accuracy and precision measures by grid size for Unit 1

Grid Size (TRUs)	Grid Error %	s Grid Error	Mean TRU Error	Mean TRU s	Phase I "zero" TRUs	Phase I TRU count	Phase II TRU count	Phase I TRU s	Phase II TRU s	Phase I/II s Ratio
2	−92.6	42.1	2.4	1.6	0.97	1.0	3.9	0.0	1.6	0.0
3	−86.0	57.7	2.7	1.3	0.94	2.0	5.2	0.0	1.3	0.0
4	−93.4	28.1	2.0	1.8	0.99	1.9	9.7	0.9	1.7	0.3
5	−100.0	0.0	1.5	0.9	1.00	0.0	8.5	0.0	0.9	0.0
6	−85.1	42.1	2.3	2.1	0.98	4.2	21.9	1.7	1.9	0.5
7	−86.6	38.0	2.1	2.0	0.99	4.2	28.8	1.4	1.8	0.5
8	−68.3	55.0	2.5	3.3	0.97	11.1	39.0	3.1	2.8	0.8
9	−70.8	50.6	2.4	3.4	0.98	11.1	48.3	2.8	3.0	0.8
10	−75.8	41.8	2.3	3.1	0.98	11.1	58.0	2.4	2.8	0.8
11	−80.2	34.4	2.3	2.9	0.99	11.1	71.0	2.1	2.6	0.7
12	−79.2	29.5	2.5	3.2	0.98	16.7	87.5	2.9	2.8	1.0
13	−83.3	23.6	2.4	3.0	0.99	16.7	100.5	2.6	2.7	0.9
14	−86.7	18.9	2.3	3.0	0.99	16.7	115.0	2.3	2.7	0.8

Table 6.9. (continued)
Lithic counts calibration: Means for accuracy and precision measures by grid size for Unit 2

Grid Size (TRUs)	Grid Error %	s Grid Error	Mean TRU Error	Mean TRU s	Phase I "zero' TRUs	Phase I TRU count	Phase II TRU count	Phase I TRU s	Phase II TRU s	Phase I/II s Ratio
2	-76.9	69.3	9.7	12.7	0.93	6.8	29.0	4.7	12.8	1.5
3	-76.4	52.3	7.9	11.9	0.95	11.4	55.3	5.0	12.8	1.3
4	-86.3	33.4	9.7	14.8	0.94	21.3	110.6	4.1	16.1	0.4
5	-73.7	42.5	7.6	12.6	0.94	27.8	140.1	4.9	12.5	1.4
6	-74.6	33.6	9.0	15.5	0.94	47.9	248.8	5.7	16.1	1.2
7	-83.1	20.8	8.5	13.3	0.94	66.7	279.0	5.1	14.3	0.7
8	-91.5	7.6	8.4	18.9	0.96	33.3	302.3	4.0	20.6	0.2
9	-62.9	32.6	9.4	27.0	0.93	83.3	424.3	8.5	28.4	1.5
10	-66.9	25.5	10.5	27.2	0.93	116.7	566.3	9.4	28.4	1.4
11	-78.5	2.2	12.8	33.1	0.92	172.2	797.0	10.7	35.7	0.3
12	-80.8	2.2	13.5	35.5	0.92	191.7	995.0	10.2	39.3	0.3
13	-76.4	1.5	12.5	33.3	0.91	250.0	1057.0	11.5	36.8	0.3
14	-76.1	0.4	11.9	31.7	0.91	266.6	1116.0	11.0	35.0	0.3

Table 6.9. (continued)
Lithic counts calibration: Means for accuracy and precision measures by grid size for Unit 3

Grid Size (TRUs)	Grid Error %	s Grid Error	Mean TRU Error	Mean TRU s	Phase 1 "zero' TRUs	Phase I TRU count	Phase II TRU count	Phase I TRU s	Phase II TRU s	Phase I/II s Ratio
2	-73.9	58.5	24.6	27.1	0.86	40.1	109.6	18.5	32.1	0.9
3	-84.8	24.8	21.2	31.1	0.88	67.5	200.2	13.3	38.0	0.5
4	-72.0	34.4	18.2	26.1	0.89	98.1	272.1	16.2	32.8	0.6
5	-77.2	27.5	15.4	34.1	0.90	95.8	326.8	12.4	39.6	0.4
6	-72.5	18.6	20.3	41.3	0.88	220.8	612.3	21.3	48.6	0.7
7	-79.8	22.3	24.3	53.0	0.87	354.1	989.1	23.6	58.2	0.3
8	-59.6	6.4	30.9	67.3	0.81	583.3	1565.0	35.4	75.5	0.7
9	-63.0	7.0	29.2	65.0	0.83	583.3	1597.0	33.8	73.0	0.7
10	-52.3	14.9	25.8	62.4	0.83	644.4	1660.0	34.5	68.6	0.9
11	-51.6	15.1	24.4	65.1	0.85	733.3	1807.0	36.3	70.2	0.7
12	-61.3	6.8	26.6	74.5	0.84	883.3	2449.0	36.8	84.4	0.5
13	-56.6	9.9	26.8	70.9	0.83	1092.0	2739.0	37.5	79.5	0.6
14	-64.3	1.3	33.3	91.6	0.81	1417.0	3957.0	40.0	104.9	0.4

Table 6.9. (continued)
Lithic counts calibration: Means for accuracy and precision measures by grid size for Unit 5

Grid Size (TRUs)	Grid Error %	s Grid Error	Mean TRU Error	Mean TRU s	Phase I "zero' TRUs	Phase I TRU count	Phase II TRU count	Phase I TRU s	Phase II TRU s	Phase I/II s Ratio
2	139.5	949.9	5.8	3.3	0.90	3.4	5.3	0.0	3.3	0.0
3	203.7	671.6	6.5	6.4	0.81	7.8	10.1	4.6	2.3	2.1
4	65.9	287.6	5.7	6.0	0.84	9.3	13.2	3.8	3.1	3.4
5	126.8	276.7	6.3	8.0	0.80	15.3	18.5	6.2	3.1	5.7
6	-13.6	107.1	4.9	6.7	0.91	20.8	29.8	6.3	3.5	3.9
7	-13.6	84.9	4.8	7.6	0.92	27.1	37.9	6.9	3.8	3.8
8	-35.9	35.6	5.6	9.3	0.94	44.4	75.3	8.7	5.7	1.6
9	-36.5	32.9	5.1	8.6	0.94	50.0	86.3	8.0	5.2	1.6
10	-39.9	33.5	4.5	8.1	0.94	50.0	93.0	7.5	4.9	1.6
11	-24.8	44.8	4.5	8.8	0.94	66.7	98.7	8.3	4.6	1.9
12	-18.9	66.6	4.8	8.3	0.92	83.3	119.0	8.0	4.5	1.8
13	-11.5	32.0	5.1	9.4	0.92	108.3	128.5	9.4	4.5	2.1
14	-28.4	8.8	5.1	9.0	0.93	108.3	151.5	8.9	4.7	1.9

Table 6.9. (continued)
Lithic counts calibration: Means for accuracy and precision measures by grid size for Unit 6

Grid Size (TRUs)	Grid Error %	s Grid Error	Mean TRU Error	Mean TRU s	Phase I "zero' TRUs	Phase I TRU count	Phase II TRU count	Phase I TRU s	Phase II TRU s	Phase I/II s Ratio
2	-6.9	346.8	6.2	5.1	0.92	2.1	7.8	1.8	4.6	1.6
3	-53.7	113.4	4.2	7.1	0.95	3.1	11.8	3.0	5.5	3.1
4	-25.7	159.3	5.1	6.1	0.93	5.2	24.8	2.6	4.5	1.8
5	-37.4	94.5	5.4	6.8	0.93	8.3	22.7	3.1	5.1	3.0
6	-41.8	64.0	6.3	7.7	0.92	10.4	49.5	3.2	6.0	1.6
7	-44.4	67.6	6.7	8.9	0.92	12.5	67.4	3.0	7.5	1.3
8	-69.1	53.5	8.7	12.2	0.97	5.6	110.7	1.7	11.1	1.4
9	-25.8	64.3	8.2	12.8	0.91	22.2	121.7	3.9	10.6	2.6
10	-34.5	60.4	7.2	12.0	0.91	27.8	132.3	3.8	10.1	1.8
11	-48.5	49.7	7.2	11.7	0.92	33.3	145.0	4.5	10.3	1.5
12	-54.0	50.9	8.0	13.9	0.91	41.7	198.0	4.7	12.7	1.4
13	-68.0	31.5	7.5	13.4	0.93	41.7	217.0	4.4	12.6	0.9
14	-79.5	9.0	7.9	15.5	0.92	50.0	269.5	4.5	15.3	0.3

Table 6.9. (continued)
Lithic counts calibration: Means for accuracy and precision measures by grid size for all units

Grid Size (TRUs)	Grid Error %	s Grid Error	Mean TRU Error	Mean TRU s	Phase I "zero' TRUs	Phase I TRU count	Phase II TRU count	Phase I TRU s	Phase II TRU s	Phase I/II s Ratio
2	-31.2	423.2	10.9	12.7	0.91	12.9	37.3	6.7	14.0	1.0
3	-27.1	299.0	8.9	13.6	0.91	19.8	61.4	6.0	14.7	1.3
4	-42.7	157.3	8.2	11.7	0.92	27.6	87.5	6.0	12.6	1.3
5	-32.1	154.1	7.3	12.9	0.91	30.2	106.1	5.4	12.8	2.1
6	-57.5	63.9	8.6	14.7	0.93	60.8	192.4	7.6	15.2	1.7
7	-61.5	58.0	9.3	17.0	0.93	92.9	280.4	8.0	17.1	1.4
8	-64.9	37.1	11.2	22.2	0.93	135.5	418.4	10.6	23.1	0.9
9	-51.8	40.0	10.9	23.4	0.92	150.0	455.6	11.4	24.1	1.4
10	-53.9	36.3	10.1	22.6	0.92	170.0	501.9	11.5	22.9	1.3
11	-56.7	36.1	10.2	24.3	0.92	203.3	583.7	12.4	24.7	1.0
12	-58.8	38.0	11.1	27.1	0.92	243.3	769.7	12.5	28.8	1.0
13	-59.2	31.9	10.8	26.0	0.91	301.7	848.4	13.1	27.2	1.0
14	-67.0	23.0	12.1	30.2	0.91	371.6	1122.0	13.3	32.5	0.7
21	-68.3	.	9.1	25.1	0.92	416.6	1314.0	10.2	27.3	0.4
29	-73.7	.	7.8	21.8	0.93	466.6	1775.0	8.4	23.5	0.4

curacy because the lack of change reflects the fact that the average error stays the same.

Those variables whose means increase are functions of grid size. The increase in the means for the three *s* measures is a surprise given the expectation that they would decrease with increasing grid size. The explanation for this discrepancy lies in the fact that each grid represents a different population. With smaller grid sizes, the proportion of low-variance grids is greater because the amount of empty or nearly empty space is greater than the amount of space covered by high-variance "hot spots." As grid size increases the average concentration size increases, as does the probability that each grid (for which the *s* measures are computed) contains at least one large concentration. The important point is that as grid sizes increase the individual grids tend to look more and more alike, each containing many small packages and some large ones. At the same time, since the underlying population is divided into fewer concentrations, a smaller number of different populations are represented. With increasing grid size, average variance increases, largely because the number of grids with zero variance declines. Meanwhile the occasional high-variance grids begin to blend with the others. The result of this process is that, while there is a moderate overall increase in variance (or *s*), the variability in these figures declines markedly.

Those variables whose means decrease—the *s* of grid error and the Phase I/II *s* ratio—are direct measures of precision. The *s* of the grid error clearly shows how (for each unit) the variability in error declines with increasing grid size. This is evidence that the error stabilizes at some level, as expected. Similarly, the decline in the Phase I/II *s* ratios indicates that the Phase I *s* becomes a better estimator of the population variance as grid size increases. Units 1 and

5 do not conform well to this pattern, possibly indicating that very low densities, even when dispersed, appear aggregated owing to the increase in empty space.

Figures 6.1 through 6.4 show how the variability in the statistics in Table 6.9 declines with increasing grid size. Because of the differences between this method of calibration and ones that use multiple sample runs, precision cannot be measured by direct comparison of variances. Consequently, precision is herein defined as the grid size at which variability in the various measures stabilizes. A graphic method of reviewing the calibration results was chosen because no legitimate mathematical alternative was suggested. In addition, since the points that appear in the figures represent individual grids, the multiple populations effect (i.e., the fact that each grid is a TRU sample of a separate population) is more honestly represented. (Note: In Figures 6.1–6.4, grids with the same value and thus the same position in the plot are represented as "B" for two grids, "C" for three, etc.).

All the figures show the same trend: reduced variation among grids. As noted, the decline in variability reflects increasing homogeneity, which is produced by blending high and low density areas. In some of the figures such reduced variation is clearly evident in the form of isolated lines representing high-density grids whose *s* or error gradually drops with increasing grid size. The phenomenon is perhaps most evident in the Phase I *s* for Unit 5 and the Phase II *s* for Units 2, 3, and 6.

Figure 6.1 compares the Phase I and Phase II *s* for each unit; it can be seen that both the estimate and population *s* decline. Figure 6.2 presents Phase I and II *s* for a simulated square kilometer composed of Units 1, 2, 5, and 6 and thus represents four times as much space as the individual plots in Figure 6.1. One consequence of the 500 m size of the Phase II units is that as grid sizes approach the maximum of 14, the differences in registration become negligible and the amount of redundancy in the statistics being compared increases. As a result, the decrease in variability is probably as much a function of this redundancy as it is of increasing precision. The use of simulated data, as depicted in Figure 6.2, overcomes this problem to some extent.

Figure 6.3 consists of plots of the Phase I/II *s* ratios for each unit. All but Unit 1 indicate a marked decline in variability in the *s* ratios. The data for Unit 3 suggest less variability overall and presumably reflect the greater degree of ubiquity and the higher density present.

Finally, Figure 6.4 shows the grid error statistics for all units and is reflective of both precision and accuracy in that the point of precision is defined as the level at which the error stabilizes and is also the point at which the mean error becomes a useful estimate of the actual bias or inaccuracy present in the sampling design. Again, the Unit 3 data stabilize at a lower grid size than the other units, suggesting that landscapes of this type were better sampled than the more common ones represented by Units 1, 2, 5, and 6. Interestingly, there appears to be as much variation within the cluster types as there is between them. For example, Units 1 and 5 (both Cluster 1) are more similar to Units 2 and 6 (Cluster 3) than they are to each other. The differences may be a function of differences in the actual distributions or perhaps are a chance function of registration.

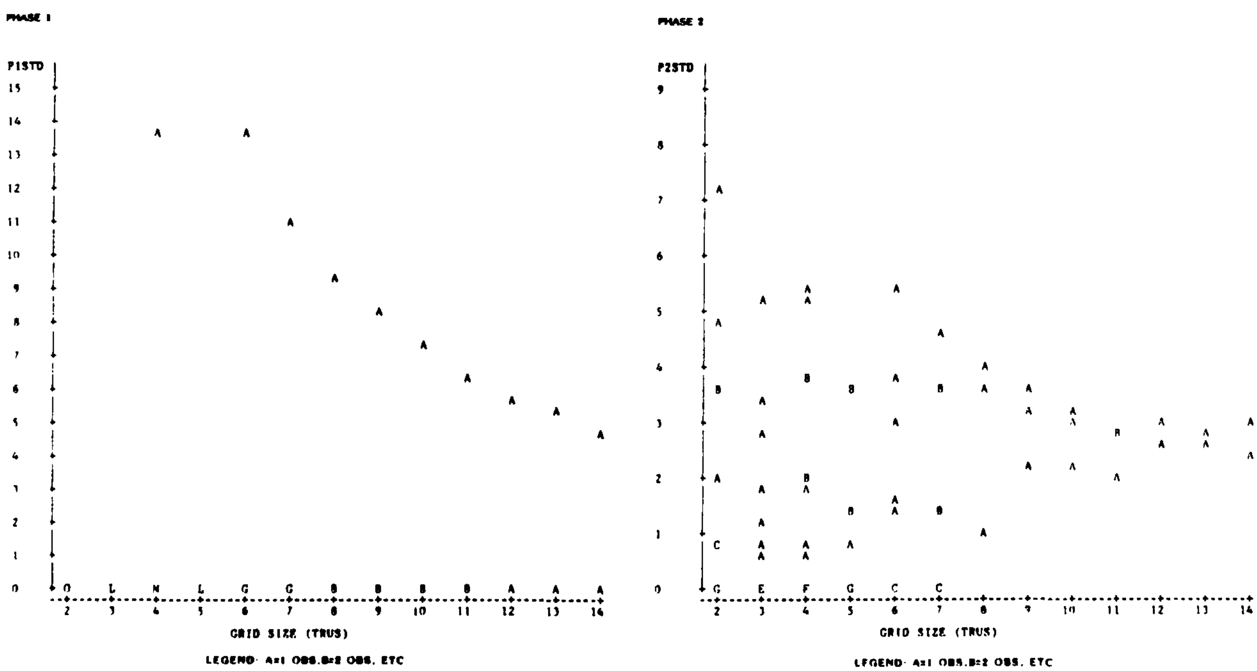


Figure 6.1. Grid TRU variance vs grid size for Phase I and II counts—Unit 1

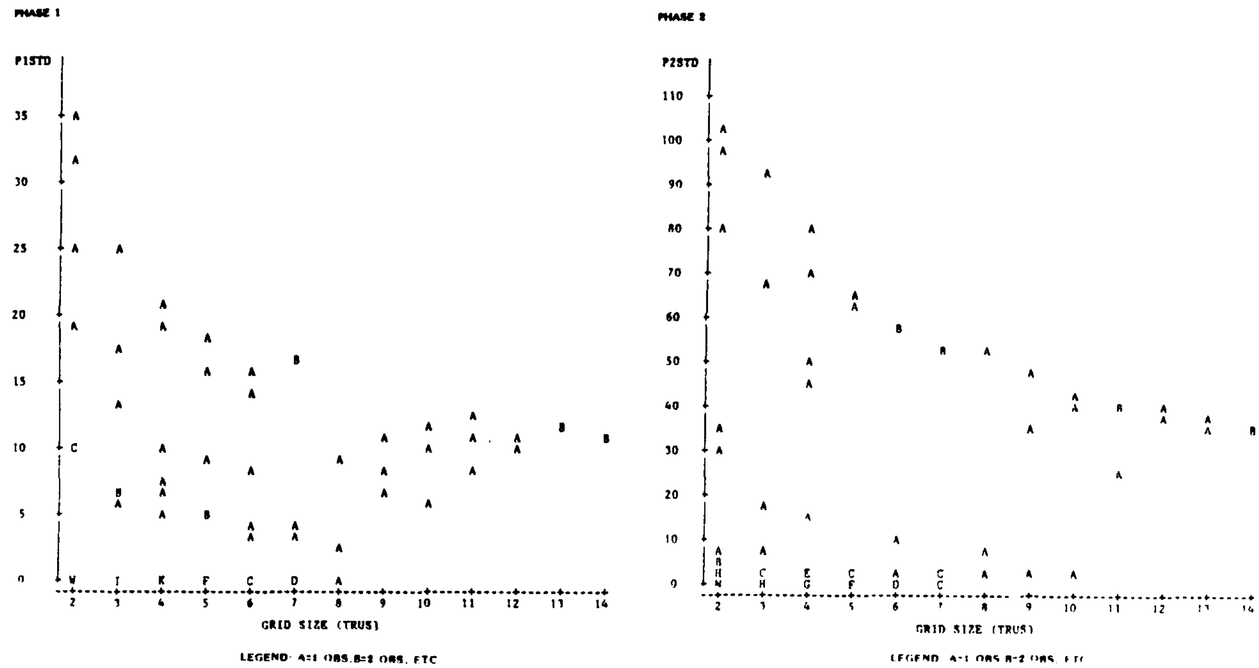


Figure 6.1. (continued) Unit 2

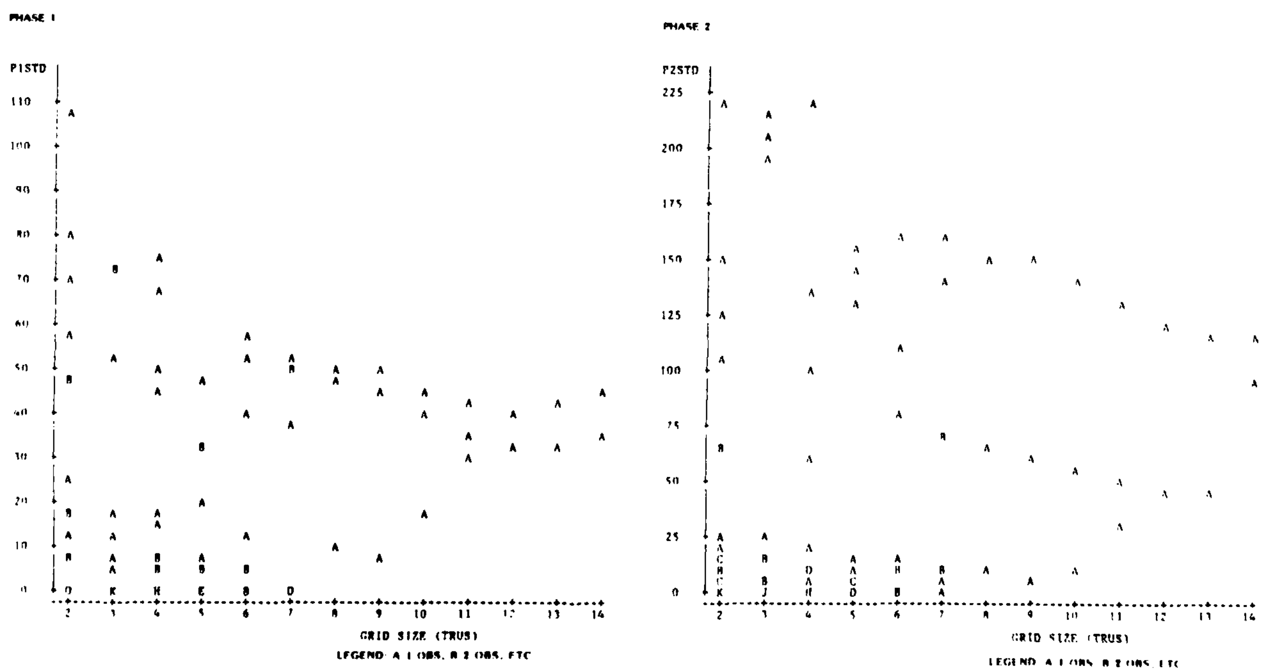


Figure 6.1. (continued) Unit 3

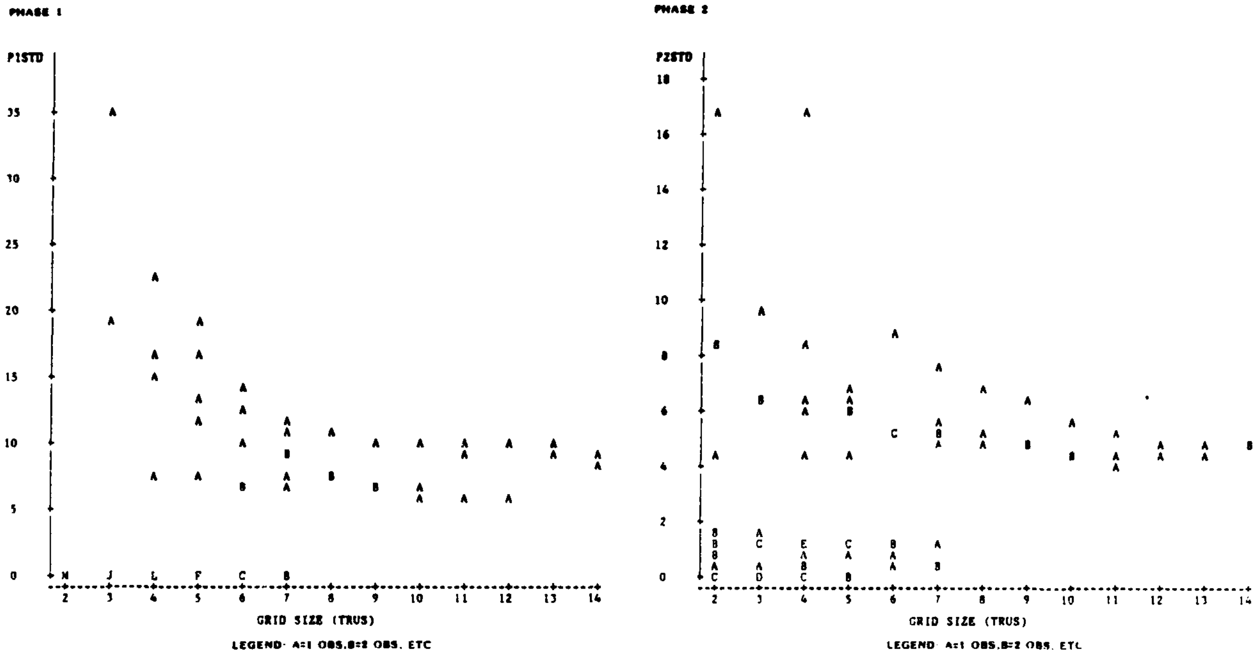


Figure 6.1. (continued) Unit 5

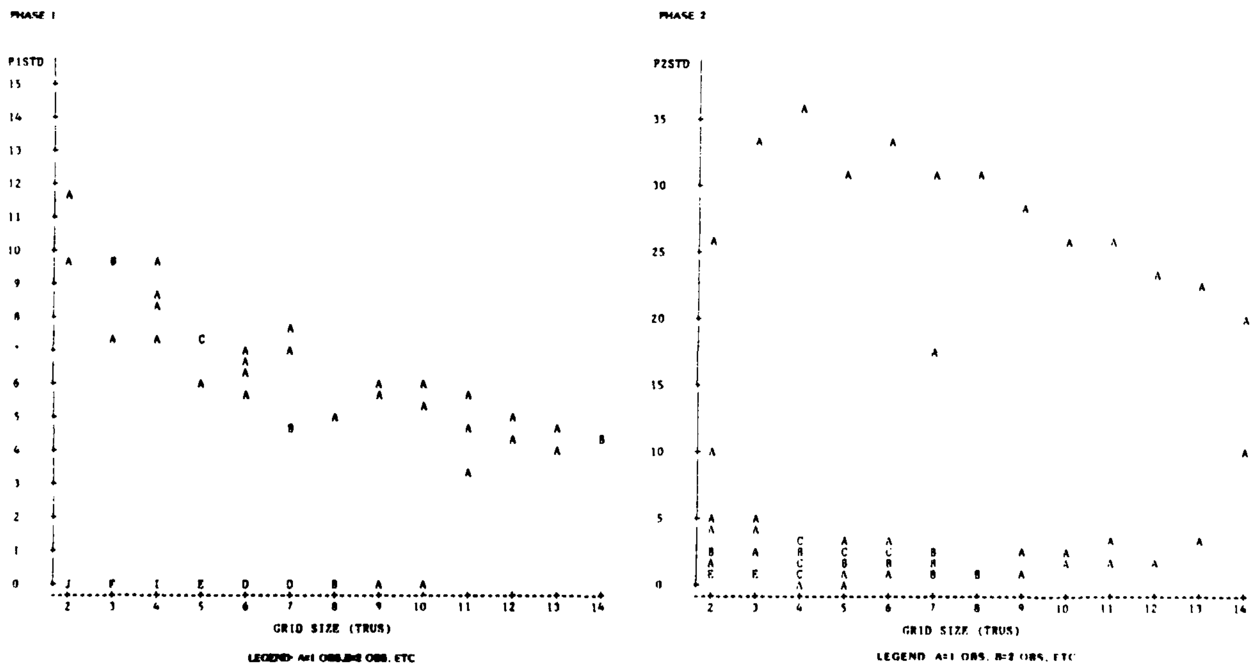


Figure 6.1. (continued) Unit 6

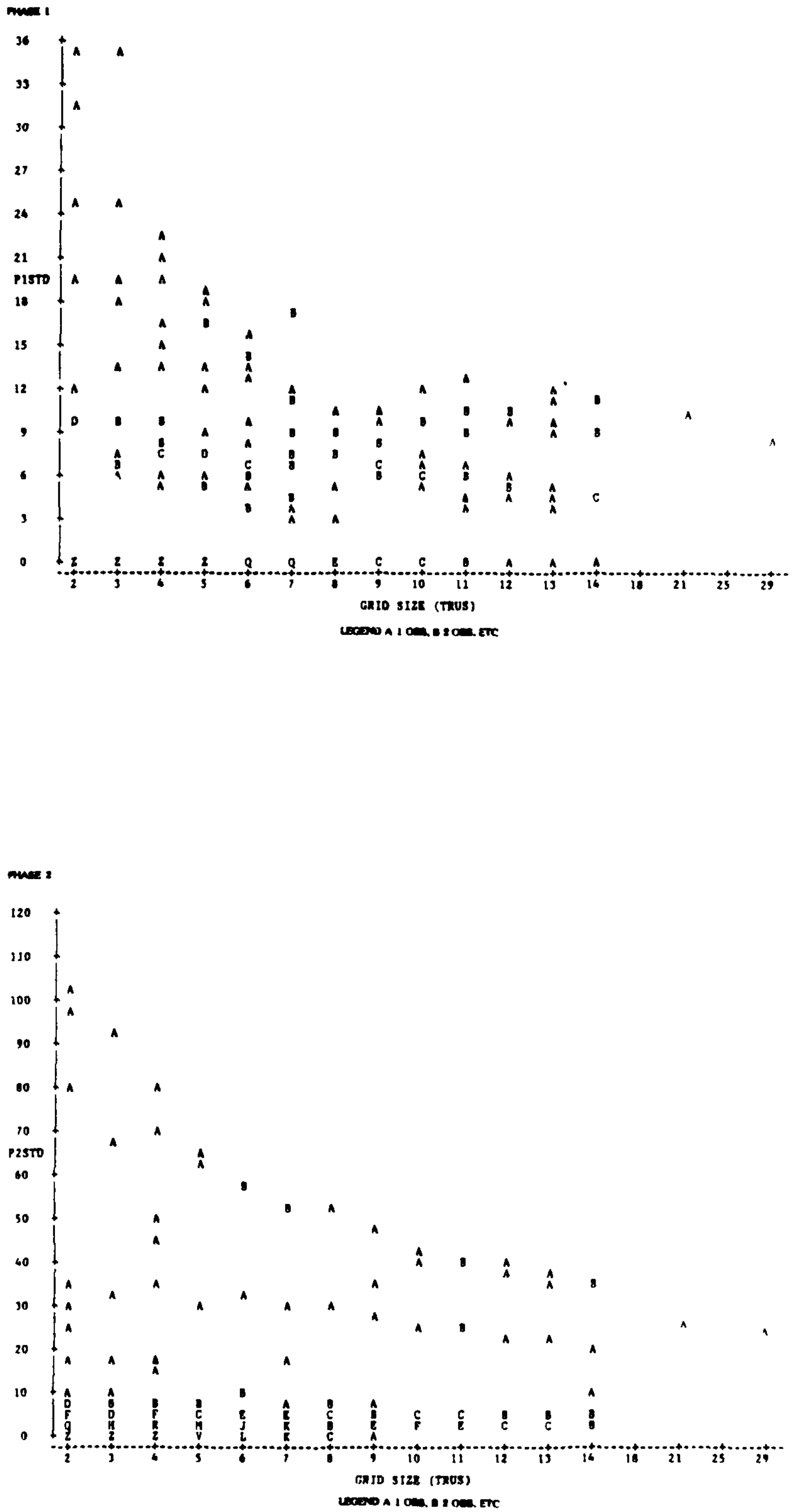
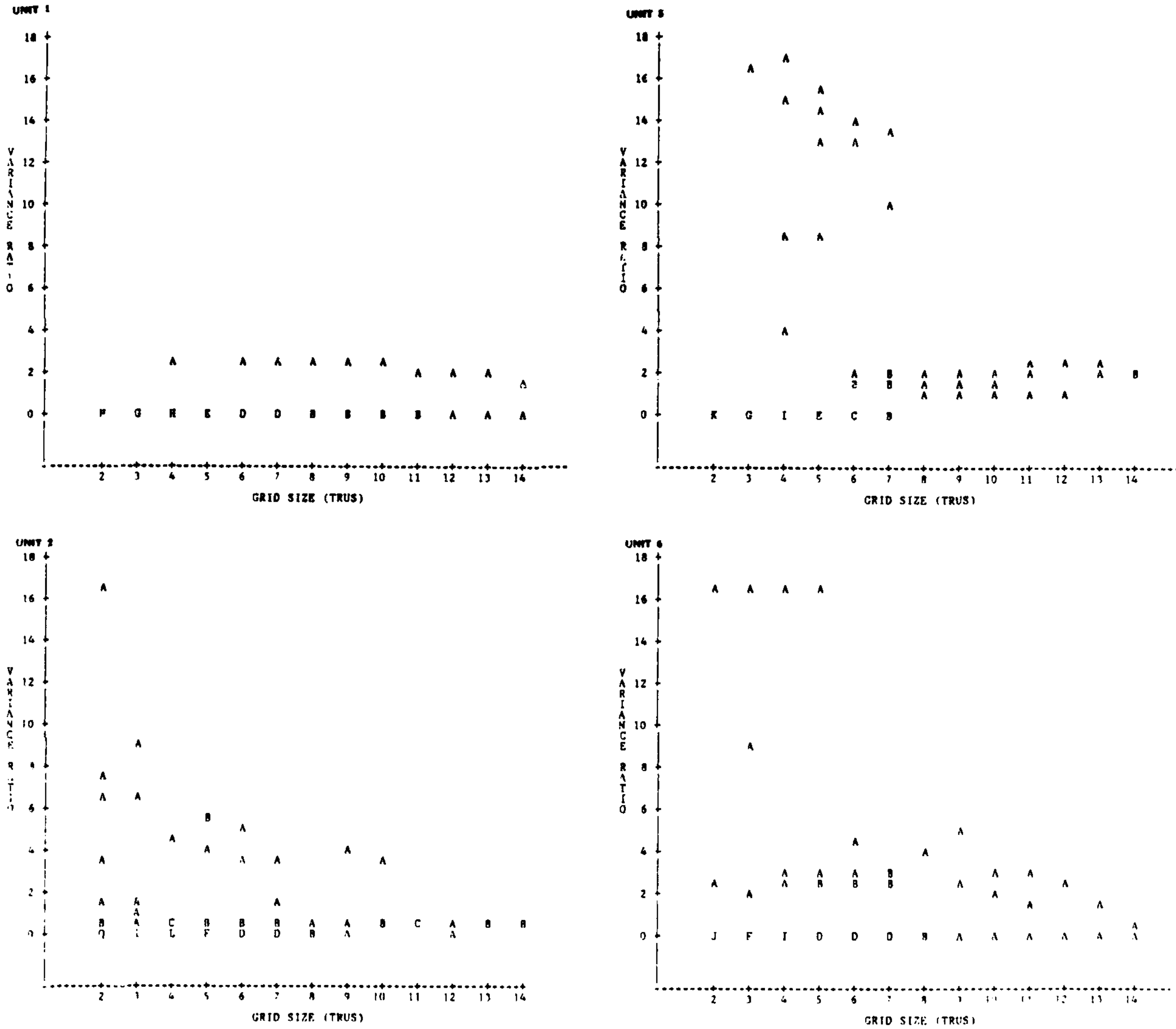


Figure 6.2. Phase I and II TRU STDS for the simulated square kilometer



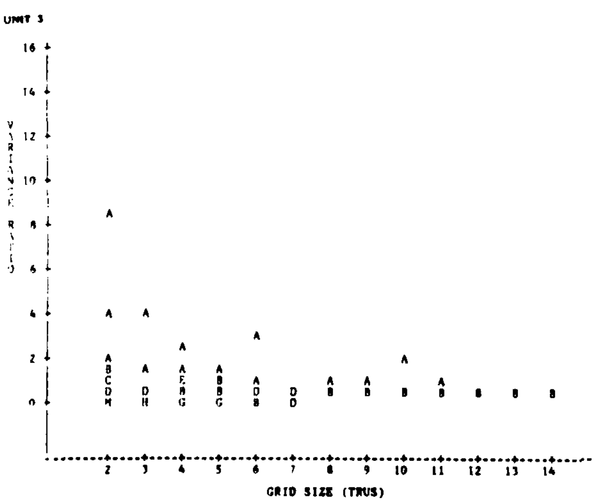


Figure 6.3. Lithic counts calibration: Ratio of Phase I/II variances vs grid size

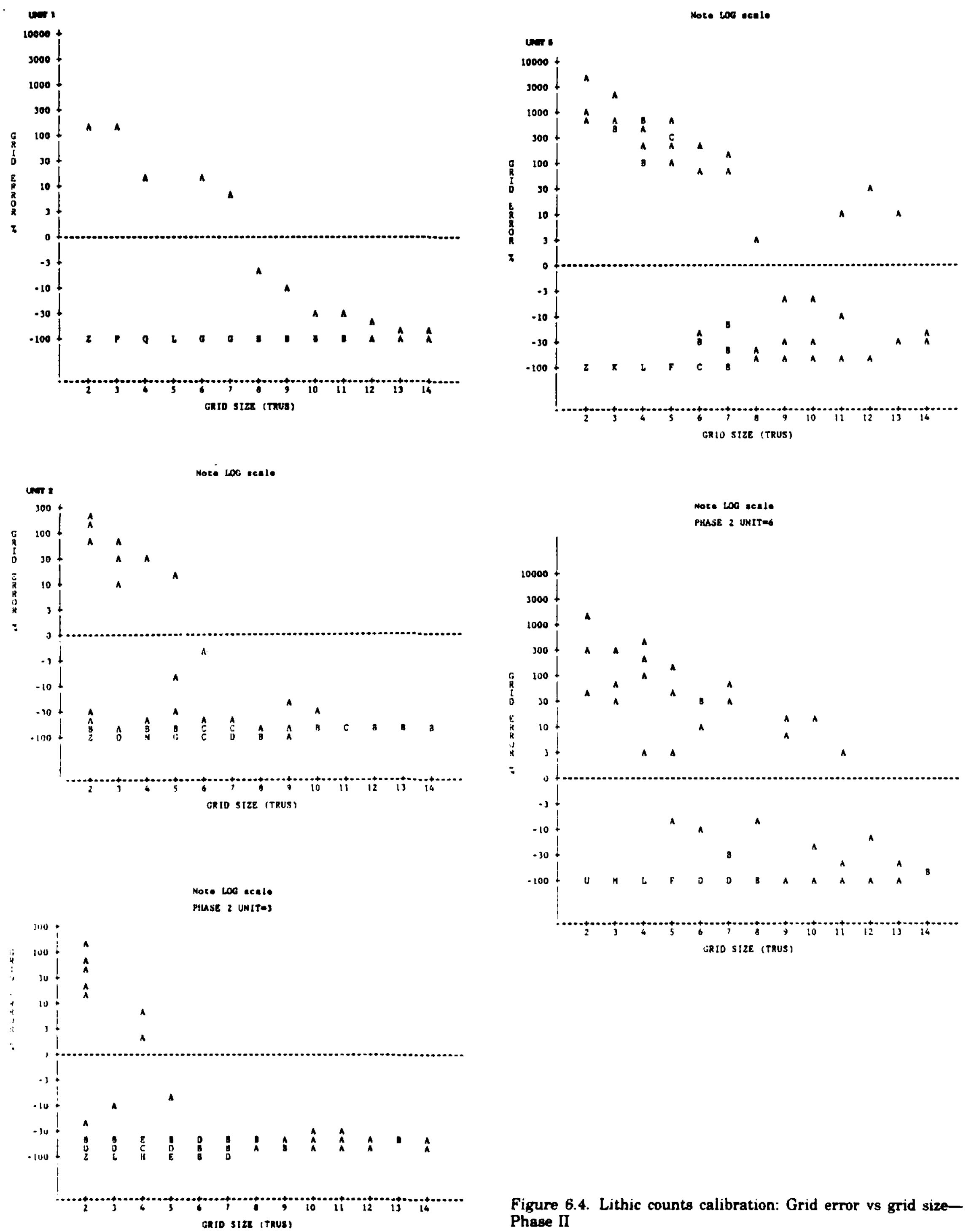


Figure 6.4. Lithic counts calibration: Grid error vs grid size—Phase II

For purposes of determining an acceptable level of precision, it was hoped that the distribution of the measures presented in Table 6.9 and Figures 6.1–6.4, when considered together, might evidence trends suggestive of the effective resolution of the TRU data for lithics. Table 6.10 is based on an inspection of the variability in *s*, *s* ratios, and grid error for each unit and estimation of the grid size above which no further reduction in variability is evident. In statistical terms, this should be the level at which increasing grid size yields no appreciable gain in precision. The "?" for the *s* ratios for Unit 1 reflects the absence of any change in the ratios at any grid size (all are very low). The "?14" entries for Unit 1 Phase I *s* and Unit 6 Phase II *s* indicate that the variability appears to stabilize at the 14–TRU cutoff imposed by the 500–m grid size.

The results exhibit less patterning than might be hoped. There is no clear-cut relationship between either the different measures or the units and the precision thresholds. None of the units is clearly better or worse than the others in terms of its average score. The average threshold for all units is about 10. This figure is comparable with the simulated square kilometer thresholds of 9 and 11 for the Phase I and II *s*, respectively. In general, the data suggest that the minimum effective resolution of the TRU sample of lithic counts lies somewhere between 8 and 14 TRUs or 267 and 500 m.

It is unfortunate that the 500 m grid size used in Phase II is so close to the suggested effective resolution of the TRU data, and that the trends cannot be reliably projected beyond this level except by the use of a simulated 1 sq km landscape. Since the simulated data approximate the individual grid results, however, it may be safe to assume that an overall figure of 10 TRUs (333 m) is generally representative.

Conclusions

The implications of this analysis for landscape studies are that the minimum grid size that can be used with any reliability is about 10 by 10 TRUs (or 333 m on a side). Since this figure is for lithic artifacts, the most common and ubiquitous item on the Border Star 85 landscape, it can be anticipated that the effective resolution of the TRU data for counts of rarer and more aggregated artifact classes is larger than that for lithics. Much of the time allocated to the calibration process was involved in developing measures and designing and performing the extensive computations required to impose different-sized grid systems sequentially on spatial data. Nonetheless, from a theoretical perspective, the increased aggregation and lower density associated with less common artifact classes are expected to reduce precision even further. Thus, the effective resolution of the TRU data for ceramics and rarer classes of data can only be expressed in terms of even larger grid sizes.

Table 6.10. Effective resolution thresholds for calibration analysis variables for Phase II Units 1, 5, 2, 6, 3, and "Sq km"

Phase II Unit	Phase I s	Phase II s	Phase I/II Ratio	TRU s	Grid Error
1	14?	11	?	10	10
5	9	11	8	8	14
2	12	12	11	11	7
6	12	14?	10	9	12
3	11	14	8	11	6
"Sq km"	9	11	.	.	.

Much archeological analysis consists of comparing assemblages of artifacts and features in terms of relative composition expressed as proportions or percentages. As we have seen, the variance of a proportional estimate and the effective sample size are severely affected by significant variations in cluster size. In the cluster sampling model of the TRU data, the TRUs are the clusters and thus will always exhibit considerable variation in counts regardless of grid size. The value of increasing grid size thus lies in increasing the overall number of elements sampled without increasing the mean cluster size. The point at which the cluster size variance (Phase I *s*) stabilizes may represent the point at which the increasing variance introduced by adding more clusters to the sample (increasing grid size) begins to be outweighed by the increase in the number of elements in the sample. This line of thinking is in keeping with Nance's caution to use many small units for cluster sampling of aggregated space (Nance 1981:165); furthermore, the use of many small sample units also reduces the effects of low intracluster homogeneity. The latter may represent a problem of even greater magnitude at landscape scales than the problems created at individual sites, for any assumptions of functional differentiation of cultural landscapes imply at least some variation in the proportional content of the artifact/feature concentrations (sites), which are the source of the problem in the first place.

The calibration analysis was unable to address directly the question of sampling precision as discussed by Nance, since no proportional estimate calibration was performed and no direct estimates of the variance of the estimate using the appropriate equation (Cochran 1977:66) were computed. As a result, we can only assume that the effective resolution as determined by the lithic counts calibration is a clue to effective resolution in terms of Nance's "statistical precision," and that stabilized variability is a precursor of stabilized cluster size variance.

Based on the above, a minimum grid size of 300–500 m for mapping landscape densities of common artifact types is recommended. For rarer item classes, 1 km is probably safer. For proportional estimates (which are sensitive to both cluster size variance and variations in the individual cluster deviations from p), 500 m to 1 km is probably a minimum. It is important to note that these estimates are not based on robust statistical analysis but on an informed assessment of the data presented above. The 500 m densities for various artifact classes presented in Figure 6.1 indicate that moderately rare artifact classes, such as chipped stone tools and cores, are fairly common at the 500 m scale. It is possible, then, that gross variations in assemblage content computed at the 1 km level—or even the 500 m level—may reflect actual variations in land-

scape content. Finally, the choice of a level of effective resolution is unfortunately a function of density and aggregation. Thus, 500 m may suffice for certain areas while 1 km is required for some and 300 m is more than enough for others. Obviously, the choice must reflect the effective resolution required for the worst case landscapes in terms of the character of density and aggregation of cultural resources. In the Border Star 85 area, low density, aggregated cultural material are the worst case, and are also the most common.

Chapter 7

PHASE II SURVEY RESULTS

Timothy J. Seaman

The purpose of this and the following chapter is to describe the results of the Phase II survey effort and consider them in light of the research objectives outlined in Chapter 2. During Phase II 1.26 km (126 ha) were intensively (i.e., 100 percent) surveyed in six survey units. Five of these units measured 500 by 500 m (25 ha) and one measured 100 by 100 m (1 ha). The location of these units within the Border Star 85 project area is illustrated in Figure 1.3. In addition, intensive survey and collection of an extensive Paleoindian site in Area B (LA 63880) was performed during Phase I; the results are considered here along with results from the Phase II effort. This extra work was done at the request of the CE because of the location of the site near an area heavily used during the Border Star 85 maneuvers. The description and analysis of collected items from this site appear in Chapter 17.

A total of 39 archeological sites documented during intensive survey are described here. Site boundaries were defined after completion of data collection and processing using quantitative criteria. First, plots of total artifact density were made for each survey unit using the 2 by 2 m grids. These grids were then lumped into 10 by 10 m blocks registered within the existing grid system, and data observations were totaled. Contiguous blocks with at least five artifacts and/or features were combined to form sites, and unique site numbers were associated with those observations. These definitional criteria were applied to all Phase II survey units except where roads and cleared areas were located within or cut across otherwise continuous distributions. Site size estimates were subsequently computed using the formula for an ellipse $\pi(ab)$, where a and b represent one-half the maximum east-west and north-south dimensions, respectively.

The choice of 10 by 10 m blocks for the purpose of site definition was based on two factors. First, the size of these blocks is convenient for combining data observations from the 2 by 2 m grids used in field data recording. Second, this method tends to filter out the effects of coppice dunes on artifact density patterns. At grid sizes less than 10 by 10 m it was found that the size and spacing of coppice dunes in most of the Phase II survey units effectively masked any continuity in artifact distributions. By using the 10 by 10 m units, these effects are averaged out.

Only those areas defined as archeological sites according to the above criteria are described in this section. Although off-site artifact distributions (isolated occurrences) sometimes appeared to represent very sparse sites and, in a few cases, contained charcoal stains that yielded radiocarbon dates, they are considered here only in discussions of overall site distributions for each unit and are afforded minimal analytical treatment.

Site descriptions are ordered by Phase II survey unit and site number. After the location, topography, and vegetation of the survey unit are described, consideration is given to the overall distribution of sites and isolated occurrences within the unit. A summary of the cultural/temporal placement of sites is then provided along with information about Phase I survey results within the unit. Beyond basic locational information, the level of description afforded each site varies according to assemblage size and content. For instance, average flake dimensions and dorsal cortex data are not reported for small sites containing fewer than five complete flakes. Similarly, the spatial distribution of various items of material culture is not considered for most of the small and/or less dense sites. Artifact inventories and descriptions for the smaller sites are presented in Appendix 5.

Because most of the initially defined research questions for the project require the analytical treatment of site assemblages, and because of the demonstrated inadequacy of Phase I survey results for addressing these questions, information from the 39 sites documented during Phase II survey constitutes the only reliable basis for analysis. Clearly, these 39 sites represent a very small sample of the cultural remains in the Border Star 85 project area. In numerical terms, Phase II sites represent a 2.1 percent sample of the Phase I total (1809 sites), and judging by the considerable number of new sites defined during intensive survey (30), it is likely that this sampling fraction is a generous estimate of the actual degree to which the Phase II sites represent the entire population of cultural remains in the project area. In terms of the area surveyed, the 1.26 sq km Phase II area represents less than 0.5 percent of the 225 sq km Phase I total. In addition, many of the larger Phase II sites were only partially surveyed because of their location on the edge of a 500 by 500 m survey unit. In the case of the extremely large and dense site in Monte Carlo Gap (LA 63490), a single 500 by 500 m unit would not encompass even one-half of its total area.

It is equally clear that the Phase II data base can not be considered representative of the variability in the entire population of Border Star 85 sites. As previously outlined in Chapters 5 and 6, Phase II survey units were chosen in order to sample variability in cultural remains using landscape types (as reflected in the results of cluster analysis of Phase I data) rather than sites as the units of analysis. The next step in the selection process involved consideration of variability in the environmental and cultural/

temporal characteristics of sites within the landscape-based clusters. As a result, the Phase II sites cannot be considered a statistically representative sample of cultural remains within the Border Star 85 project area.

The sites documented during intensive survey do, however, include most cultural/temporal periods and site types relevant to the research questions, and they were documented at a level of detail appropriate to the analytical treatment described here. The sampling problems have limited the range of analyses that can be performed, however, and the reliability of analytical results should remain open to question.

Sites in Survey Unit 1

Survey Unit 1 is located in the basin floor ca. 8 km west of the Jarilla Mountains. The southwest corner of the unit is located at UTM 387000E/3597500N; Figure 1.3) and the average elevation of the unit is 1222 m. In terms of topography and vegetation, the unit is characteristic of central basin environs in the project area. Mesquite-topped coppice dunes from 1 to 3 m high interspersed with blowouts dominate most of the survey unit. A stabilized area occupies the north and northwest portions and supports a relatively dense growth of snakeweed and grasses in addition to the ubiquitous mesquite. In the more eroded portions of this unit coppice dunes occur as long linear features oriented to conform to the prevailing southwest winds.

The Phase II survey of this unit resulted in the documentation of eight archeological sites (see following pages) within a sparse but continuous cultural landscape of scattered fire-cracked rock and lithic artifacts (Figure 7.1). As defined, the site boundaries do not distinguish highly patterned clusters of cultural remains. Rather, the generalized distribution of materials in this unit is probably the

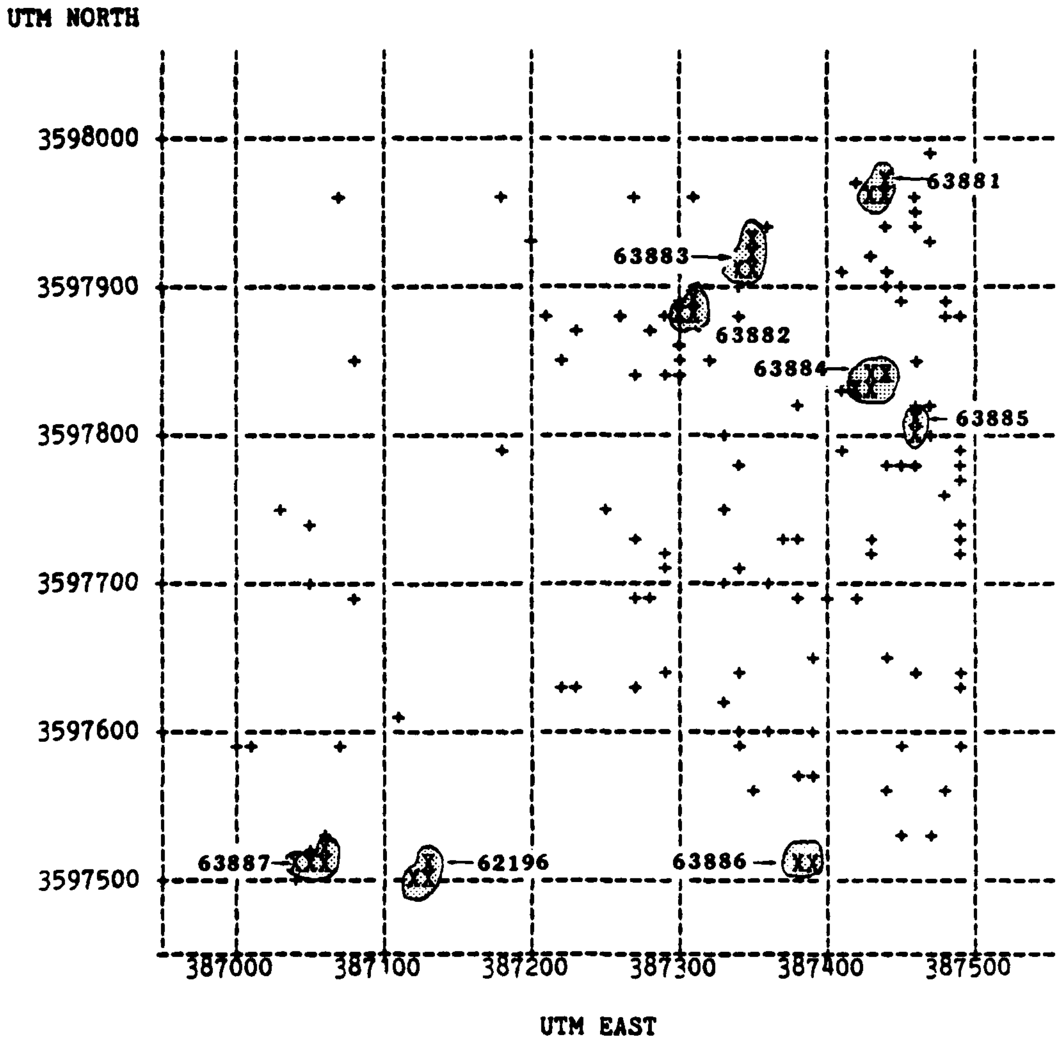


Figure 7.1. Phase II Survey Unit 1: Distribution of sites (X) and isolates (+)

result of the interaction between short-term, low-intensity occupations and erosional processes. Several isolated charcoal stains—some of which yielded radiocarbon dates—were not distinguished as sites using the criteria described above. Only one of the eight sites (LA 62196) had been documented during Phase I survey. Another site (LA 62198) was documented by Phase I survey along the extreme eastern edge of Survey Unit 1, but not enough artifacts were documented in that vicinity during Phase II survey to warrant its analytical treatment as a site. The absence of any ceramics, coupled with five radiocarbon dates ranging from 540 BC to AD 120, suggests that most of the cultural remains within this unit date from the Late Archaic to early Formative periods.

LA 62196 (WS 1196)

Location: UTM 387130E/3597508N (Figure 7.1)
Size: ca. 16 by 16 m; 201 sq m
Temporal/cultural assignment: Lithic unknown

This site is located in a heavily blown-out area enclosed by a number of high coppice dunes along the southern boundary of Survey Unit 1. Slightly less than half of this site was surveyed during Phase II. The site consists of a sparse scatter of fire-cracked rock and lithic artifacts of unknown age. The disarticulated remains of at least one feature evidencing the use of fire is represented by eight fragments of fire-cracked rock recorded within five 2 by 2 m grids; only one grid contained as many as three pieces (see Appendix 5 for more detailed information on this and other small sites).

Fifteen lithic artifacts were recorded: 12 pieces of debitage (9 flakes and 3 pieces of angular debris), 2 irregular cores, and a projectile point of unknown age and cultural affiliation. Irregular cores exhibit few or no well-developed striking platforms. Local dull cherts account for 10 of the 12 pieces of debitage. Only seven flakes were complete.

LA 63881 (WS 2881)

Location: UTM 387442E/3597966N (Figure 7.1)
Size: ca. 12 by 8 m; 75 sq m
Temporal/cultural assignment: Lithic unknown

LA 63881 is located around the heavily eroded base of a high coppice dune. The remains of one or more facilities exhibiting use of fire were recorded in six individual grids in which a total of 16 fragments of fire-cracked rock were tabulated. One was labeled a concentration and the other five were identified as scatters.

The density of the fire-cracked rock concentration—totaling eight fragments within a single 2 by 2 m grid—raises the possibility that it remains relatively intact even though it is exposed on the surface. No charcoal staining was noted. The overall density of fire-cracked rock on LA 63881 is 0.21 fragments per sq m.

Only four lithic artifacts were recorded during intensive survey of LA 63881: three complete flakes (two of dull chert and one of basalt) and a single hammerstone or maul of dull chert.

LA 63882 (WS 2882)

Location: UTM 387310E/3597885N (Figure 7.1)
Size: ca. 4 by 10 m; 31.4 sq m
Temporal/cultural assignment: Lithic unknown

This very small site is exposed in a wind-swept area between two large coppice dunes. It consists of a scatter of seven pieces of debitage (four flakes and three pieces of angular debris) made of four different materials: dull chert (three items), waxy chert (two items), and quartzite and other (one each). All four flakes were complete.

LA 63883 (WS 2883)

Location: UTM 387351E/3597923N (Figure 7.1)
Size: ca. 6 by 14 m; 66 sq m
Temporal/cultural assignment: Late Archaic (540 BC)

This site consists of a relatively dense scatter of fire-cracked rock located in a stabilized area just west of a large coppice dune. A total of 22 pieces of fire-cracked rock were recorded in six separate grids with a maximum of eight in a single grid. Four grids within this site contained fire-cracked rock in sufficient concentrations to indicate possible subsurface hearths or roasting pit features with some degree of spatial integrity. Another two grids contained less concentrated scatters, and a third contained charcoal and ash but no rock. A radiocarbon sample extracted from one concentration yielded a determination of 2490 ± 110 years BP (Sample 18; 540 BC), placing the site in the Late Archaic period.

Only a single piece of dull chert angular debris was recorded on LA 63883, but unexposed lithic artifacts are believed to exist within this site.

LA 63884 (WS 2884)

Location: UTM 387437E/3597841N (Figure 7.1)
Size: ca. 22 by 14 m; 241.9 sq m
Temporal/cultural assignment: Late Archaic (310 BC)

LA 63884 consists of a dense scatter of fire-cracked rock located within a small stabilized area among three low coppice dunes. The site contains at least one intact hearth, which yielded a radiocarbon sample dated to 2260 ± 70 years B[illegible] (S[illegible]mple 15; 310 BC). Twelve grids with fire-cracked rock a[illegible] one with a charcoal/ash stain were also recorded. A total [illegible] fragments of fire-cracked rock were recorded in 12 grid[illegible]h a mean of 4.67 and maximum of 12 pieces per grid. Overall fire-cracked rock density for this Late Archaic site is 0.23 fragments per sq m.

Only six lithic artifacts were recorded on LA 63884 during the Phase II intensive survey: a single piece of fine-grained chert angular debris, a dull chert pounding implement, and four fragmentary grinding tools—three of sandstone and one of volcanic porphyry. Three of the ground stone fragments were identified as manos.

LA 63885 (WS 2885)

Location: UTM 387464E/3597812N (Figure 7.1)
Size: ca. 8 by 8 m; 50.3 sq m
Temporal/cultural assignment: Lithic unknown

LA 63885 is a dense fire-cracked rock and lithic scatter exposed in a deep blowout enclosed on three sides by meter-high coppice dunes. A total of 42 fragments of fire-cracked rock were recorded within the boundaries of this small site, yielding a density of 0.84 fragments per sq m. Maximum number of fire-cracked rock per 2 by 2 m grid was seven. In at least four grids the density of exposed fire-cracked rock may indicate relatively intact hearths or roasting pits, although charcoal staining was not observed. Ten grids with less concentrated scatters were also recorded.

Twelve lithic artifacts were recorded on this site: debitage of both coarse-grained (3) and fine-grained (1) chert and quartzite (1), a unidirectional or "blade" core of unknown material, and six fragments of sandstone or granite grinding implements. Two of the three flakes were complete. One unidentified metate and two slab metates were identified in the ground stone collection.

LA 63886 (WS 2886)

Location: UTM 387391E/3597514N (Figure 7.1)
Size: ca. 6 by 8 m; 37.7 sq m
Temporal/cultural assignment: Late Archaic (120 BC)

LA 63886 consists of a very dense concentration of fire-cracked rock located in a steep-sided blowout surrounded by high coppice dunes. No other artifacts were recorded. A total of 91 fragments of fire-cracked rock were recorded in an area of only 38 sq m, yielding a density of 2.41 fragments per sq m—a very high figure for Survey Unit 1. One grid contained 19 fragments and was labeled a concentration; 12 other grids contained scatters. Two discrete charcoal stains were observed, one of which yielded a radiocarbon determination of 2070 ± 70 years BP (Sample 17; 120 BC).

Given the location of this early Formative period site in a deep blowout and the shallowness of the stained areas, the large amount of fire-cracked rock observed is probably due to the fact that the site is almost completely exposed by wind erosion. This situation serves to emphasize the distinct possibility that many of the less dense sites (and isolated occurrences) recorded in this unit are only minimally exposed and contain considerable subsurface deposits.

LA 63887 (WS 2887)

Location: UTM 387050E/3597515N (Figure 7.1)
Size: ca. 20 by 10 m; 157.1 sq m
Temporal/cultural assignment: Lithic unknown

LA 63887 is a very sparse scatter of fire-cracked rock and lithic artifacts located within a wide, well-stabilized area just west of a large linear coppice dune. The density of fire-cracked rock is only 0.13 fragments per sq m. Less than 13 percent of the grids within the site account for a total of 21 fragments; maximum number of pieces per grid is six.

Lithic artifacts recorded on LA 63887 consist of seven flakes (six of dull and one of fine-grained chert) and a single metate fragment of basalt. Only three of the chert flakes are complete.

Sites in Survey Unit 2

Survey Unit 2 is located on the basin floor at an average elevation of 1220 m (Figure 1.3). This unit is located near the western border of the Border Star 85 survey area (UTM 383500E/3590500N); the Jarilla Mountains lie 11 km to the east. In terms of topography and vegetation, this unit is almost identical to Unit 1 except that a large stabilized area occurs on a slight rise in the southeastern quarter of the unit. Several sites are exposed in this area.

Seven archeological sites were recorded during intensive survey of Unit 2, only two of which were discovered during the Phase I survey (LA 62896 and LA 62897). Along with the site concentration in the southeastern quarter of the unit, a continuous distribution of isolated artifacts characterizes the remainder of Survey Unit 2 (Figure 7.2). Although no ceramics were recorded within the unit and no radiocarbon samples were extracted from any of the sites, the nature of most lithic assemblages and the presence of two diagnostic projectile points on two sites indicate a Middle to Late Archaic temporal affiliation.

LA 62896 (WS 1896)

Location: UTM 383832E/3590600N (Figures 7.2, 7.3, and 7.4)
Size: ca. 120 by 140 m; 13,194.7 sq m
Temporal/cultural assignment: Middle to Late Archaic

This site consists of an extensive scatter of lithic artifacts and fire-cracked rock occupying most of a slight rise overlooking a large depression to the west and north. The material is distributed over the site in a series of concentrations that commonly correspond with eroded areas between coppice dunes (Figure 7.3).

The remains of a large number of fire-using features are represented by 448 fire-cracked rock fragments in several concentrations and by a single charcoal stain. Unfortunately, the stained area did not yield any radiocarbon samples suitable for dating. Two grids contained sufficient quantities of fire-cracked rock to be considered concentrations (a maximum of 27 per grid), while 128 grids contained scatters. In the extreme northwestern portion of the site, lithics dominate the assemblage.

Almost 90 percent (795) of the 892 lithic artifacts recorded or collected during intensive survey are debitage (Table 7.1). Also included are nine cores, a single hammer or maul, 20 chipped stone tools of various types, and 61 fragments of ground stone.

The debitage on LA 62896 represents a diverse sample of lithic material types and contains a high proportion of flakes associated with advanced stages of reduction and tool manufacture and/or maintenance. Table 7.2 illustrates not only the diversity of materials evident in the reduction debris but also the fact that fine-grained types (i.e., waxy chert, chalcedony, and obsidian) occur in greater

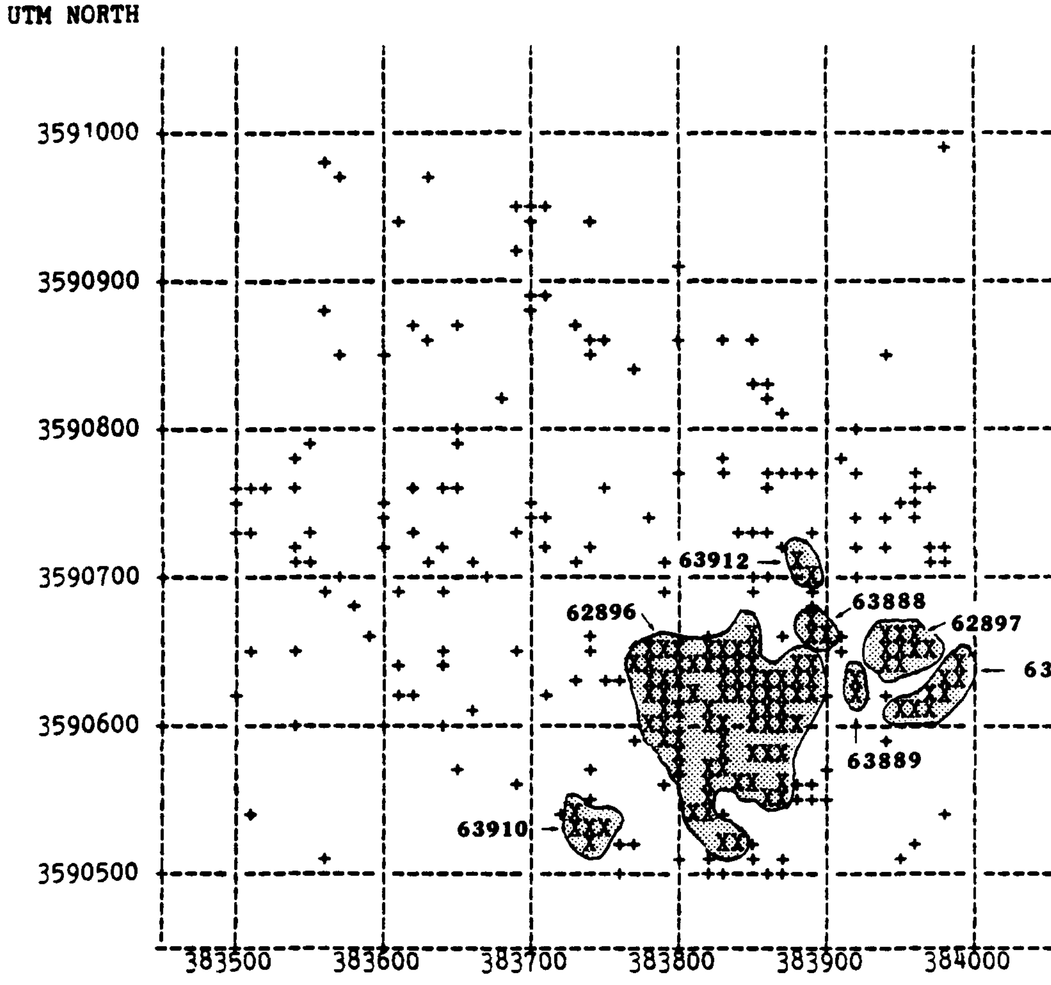


Figure 7.2. Phase II Survey Unit 2: Distribution of sites (X) and isolates (+)

numbers than the more coarse-grained types. When the miscellaneous category is excluded, 55.3 percent (436) of the debitage consists of fine-grained material types.

The vast majority of the 297 complete flakes represent advanced stages of reduction as suggested by the lack of dorsal cortex and by the platform characteristics. As Table 7.3 illustrates, almost 95 percent of the complete flakes exhibit cortex on less than 10 percent of their dorsal surfaces. In addition, almost 30 percent of the complete flakes from LA 62896 have platforms characteristic of advanced reduction and, in particular, of biface manufacturing waste (Table 7.4). Evidence for significant amounts of biface manufacturing and maintenance at LA 62896 may also be seen in the relatively high (more than 26 percent) number of bifacial thinning and sharpening flakes (Table 7.1). In addition, mean flake thickness for the site is only 3.13 mm ($n = 295$; $s = 3.02$)—a very low figure in comparison to thicknesses of flakes from other sites documented during the Phase II survey.

A single diagnostic projectile point—a stemmed point similar to the Bajada or Pandale types—was collected from LA 62896, which suggests an Early to Middle Archaic occupation.

LA 62897 (WS 1897)

Location: UTM 383958E/3590656N (Figures 7.2, 7.3, and 7.4)

Size: ca. 36 by 16 m; 452.4 sq m

Temporal/cultural assignment: Lithic unknown

LA 62897 consists of a scatter of fire-cracked rock and lithic artifacts located in a partially stabilized area between two large coppice dunes. A total of 157 fragments of fire-cracked

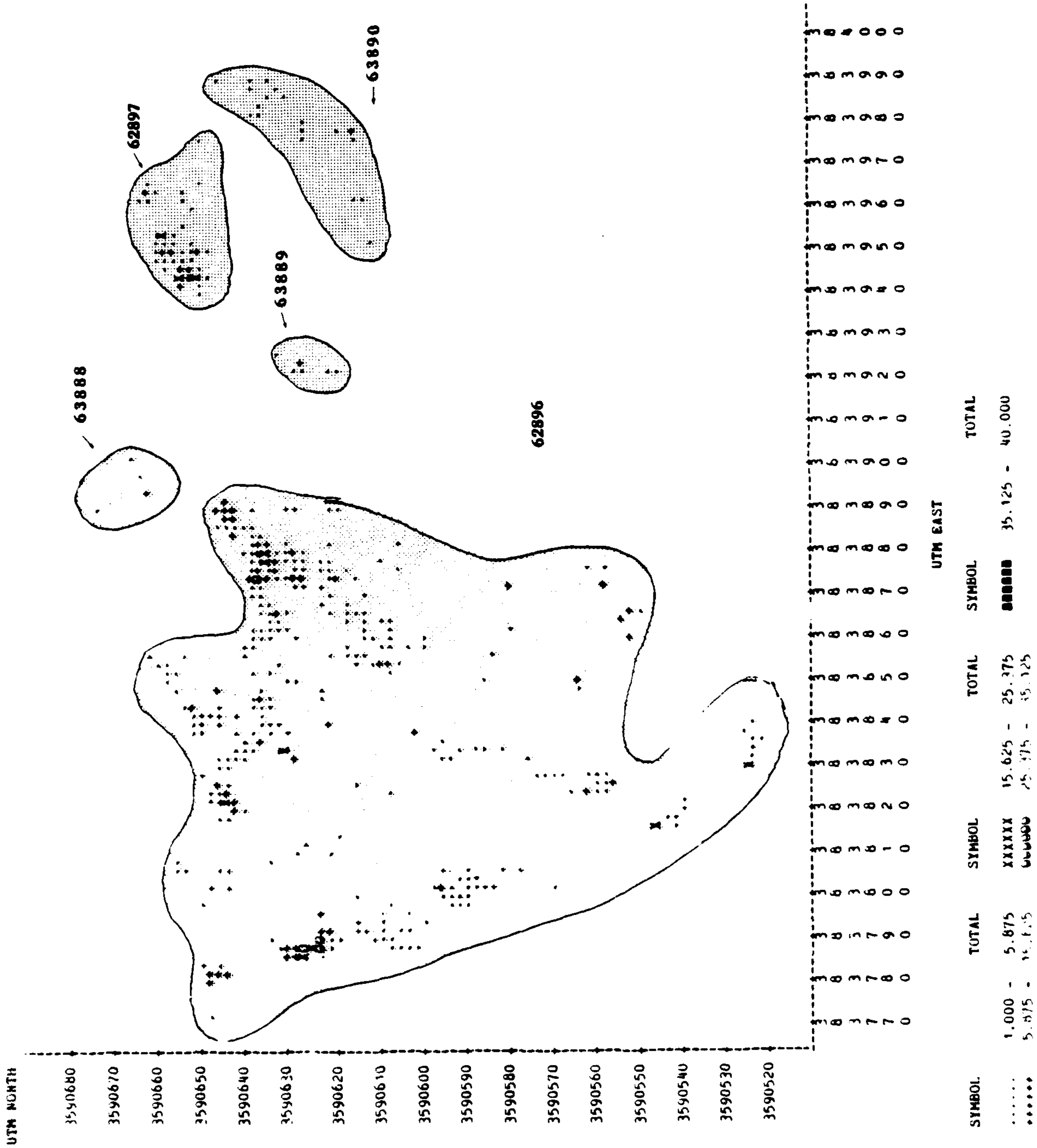


Figure 7.3. Phase II Survey Unit 2: Total artifact density at LA 62896, 62897, 63888, 63889, and 63890

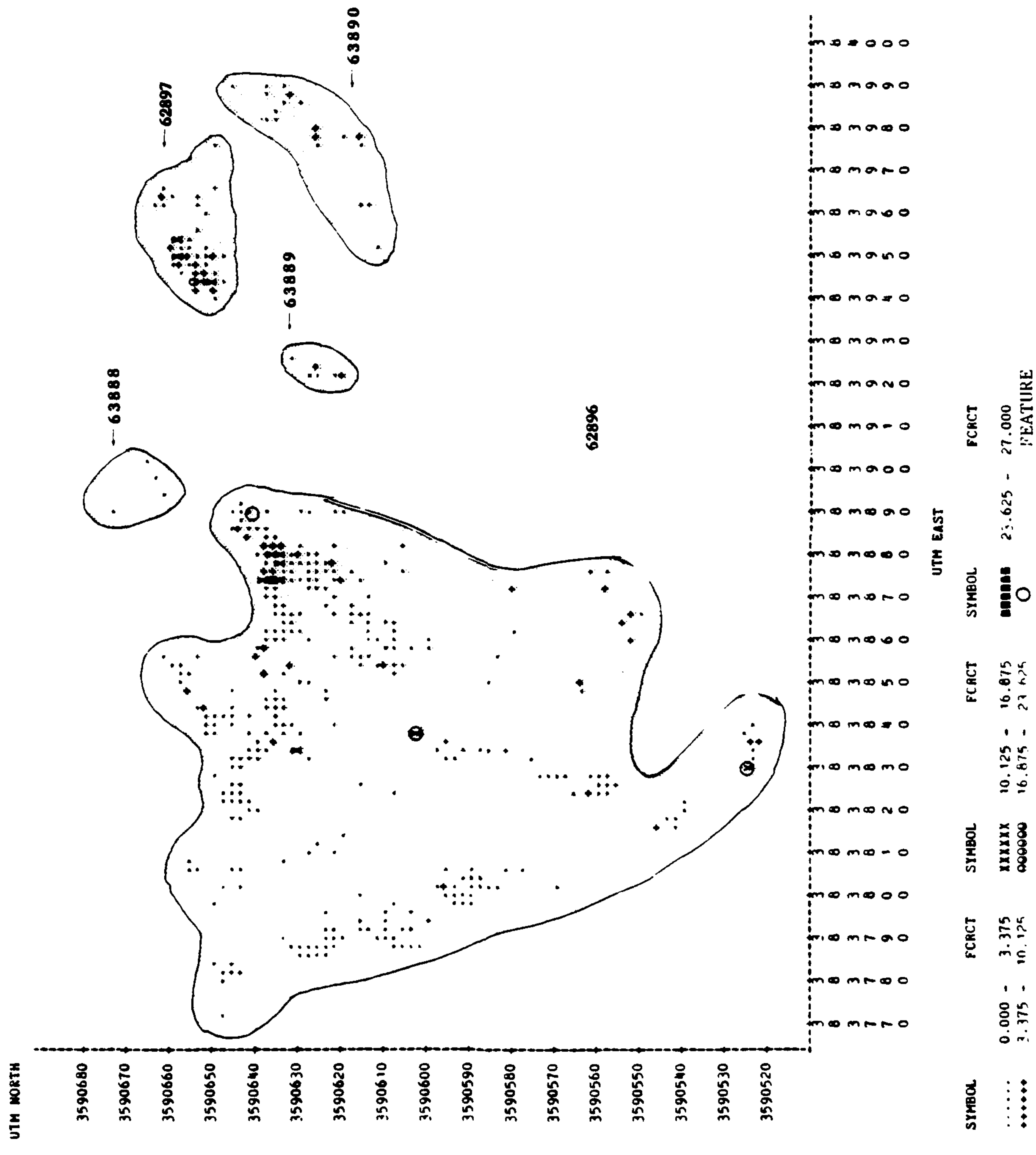


Figure 7.4. Phase II Survey Unit 2: Distribution of features and fire-cracked rock (FCR) densities at LA 62896, 62897, 63888, 63889, and 63890

Table 7.1. LA 62896 lithic artifact inventory

Lithic Type	Count	Percentage of Total	Percentage of Type
Debitage			
Angular Debris	53	5.94	6.67
Flake	529	59.30	66.54
Biface Flake	110	12.33	13.84
Sharpen Flake	103	11.55	12.96
Subtotal	795	89.12	100.01
Cores			
Irregular Core	6	0.67	66.67
"Blade" Core	3	0.34	33.33
Subtotal	9	1.01	100.00
Pounding Tools			
Hammer	1	0.11	100.00
Chipped Stone Tools			
Retouched Angular Debris	1	0.11	5.00
Retouched Flake	4	0.45	20.00
Projectile Point	1	0.11	5.00
Biface	3	0.34	15.00
Uniface	11	1.23	55.00
Subtotal	20	2.24	100.00
Grinding Tools			
Unknown Ground Stone	37	4.15	60.66
Unknown Mano	5	0.56	8.20
One-hand Mano	6	0.67	9.84
Unknown Metate	7	0.78	11.48
Slab Metate	6	0.67	9.84
Subtotal	61	6.83	100.02
Other			
Other	6	0.67	100.00
Total	892	99.98	

Table 7.2. LA 62896 debitage material summary

Material Type	Count	Percentage of Total	Percentage of Type
Waxy Chert	391	43.88	49.18
Dull Chert	309	34.68	38.87
Chalcedony	36	4.04	4.53
Quartzite	6	0.67	0.75
Obsidian	9	1.01	1.13
Basalt	13	1.46	1.64
Rhyolite	7	0.79	0.88
Sandstone	2	0.22	0.25
Carbonates	15	1.68	1.89
Other Misc	7	0.79	0.88
Total	795	89.22	100.00

Table 7.3. Amount of dorsal cortex on complete flakes from LA 62896

Cortex	Count	Percent
None	265	89.23
1–10 Percent	13	4.38
11–30 Percent	8	2.69
31–80 Percent	7	2.36
81–100 Percent	4	1.35
Total	297	100.01

Table 7.4. LA 62896 complete flake platforms

Platform	Count	Percent
N/A	6	2.02
Collapsed	35	11.78
Cortical	33	11.11
Single Facet	117	39.39
Multi Facet	17	5.72
Prepared	89	29.97
Total	297	99.99

rock were recorded in 34 grids, yielding a density of 0.35 fragments per sq m. The distribution of this material is illustrated in Figure 7.4. Maximum number of fragments per grid is 17.

The lithic artifact inventory from LA 62897 consists of 20 pieces of debitage (3 pieces of angular debris and 17 flakes), a unidirectional or "blade" core and a hammerstone of dull chert, and 7 fragments of sandstone or granite ground stone tools (one of them identified as a mano). The debitage is made up primarily of the local dull cherts (17 pieces); the remaining examples are made of fine-grained chert (two artifacts) or basalt (one artifact). The 10 complete flakes had collapsed (2) or single-facet (8) platforms, and 8 had no dorsal cortex. No temporally diagnostic artifacts were recovered from LA 62897.

LA 63888 (WS 2888)

Location: UTM 383896E/3590668N (Figures 7.2, 7.3, and 7.4)
Size: ca. 12 by 12 m; 113.1 sq m
Temporal/cultural assignment: Lithic unknown

This site consists of a very sparse scatter of fire-cracked rock and lithic artifacts exposed on the windward side of a large coppice dune 10–20 m north of LA 62896. The entire assemblage at this site consists of two fragments of fire-cracked rock (both from one grid), nine pieces of debitage, a piece of retouched angular debris (fine-grained chert), and a limestone metate fragment. The majority of debitage is fine-grained or waxy chert (seven artifacts); dull chert and rhyolite are represented by one item each. Only six flakes were complete.

LA 63889 (WS 2889)

Location: UTM 383924E/3590626N (Figures 7.2, 7.3, and 7.4)
Size: ca. 4 by 12 m; 37.7 sq m
Temporal/cultural assignment: Lithic unknown

This small site consists of a very sparse scatter of fire-cracked rock and lithic artifacts located in an open, stabilized area 20 m east of LA 62896. Sixteen pieces of fire-cracked rock were recorded on LA 63889, yielding a density figure of only 0.42 fragments per sq m. A maximum of six fragments per grid were recorded on the five grids that contained fire-cracked rock. Nine pieces of chert debitage (two waxy and seven dull) were recorded on this site; four of them were complete flakes.

LA 63890 (WS 2890)

Location: UTM 383971E/3590629N (Figures 7.2, 7.3, and 7.4)
Size: ca. 38 by 34 m; 1014.7 sq m
Temporal/cultural assignment: Middle to Late Archaic

This site consists of a sparse scatter of fire-cracked rock and lithic artifacts located in an open stabilized area east of a series of active coppice dunes. Thirty-six fire-cracked rock fragments were recorded on this site in 13 grids, yielding a density of 0.04 fragments per sq m. Maximum number of fragments per grid is five.

The lithic assemblage consists of 14 pieces of debitage (13 of them flakes), a dull chert pounding implement, an untyped fine-grained chert projectile point—probably assignable to the Middle to Late Archaic period—and two sandstone metate fragments. Debitage recorded on this site consisted of six pieces each of dull and fine-grained cherts, one of obsidian, and one of rhyolite. Only six flakes were complete.

LA 63910 (WS 2910)

Location: UTM 383746E/3590532N (Figure 7.2)
Size: ca. 20 by 16 m; 251.3 sq m
Temporal/cultural assignment: Lithic unknown

LA 63910 is a sparse fire-cracked rock and lithic scatter exposed between a series of high coppice dunes. The assemblage from this small site consists of 4 fragments of fire-cracked rock and 14 pieces of lithic waste, 1 of which was retouched. Three pieces of fire-cracked rock were found in a single grid. Most of the debitage is of dull chert (eight artifacts); fine-grained chert is represented by three artifacts, and basalt and obsidian are also represented (one example of each). There were 2 pieces of unretouched angular debris, 10 flakes, and 1 biface flake; only 6 of the flakes were complete.

LA 63912 (WS 2912)

Location: UTM 383887E/3590711N (Figure 7.2)
Size: ca. 10 by 10 m; 78.5 sq m
Temporal/cultural assignment: Lithic unknown

This site is a very sparse scatter of fire-cracked rock and lithic artifacts located at the foot of an active coppice dune. The assemblage recorded at this site consists of four fragments of fire-cracked rock, three fine-grained chert flakes, and a fragmentary mano of a carbonate material. Only one piece of debitage was complete.

Sites in Survey Unit 3

Survey Unit 3 is located on the lower slopes of an alluvial fan 1.5 km west of the flanks of the Jarilla Mountains. The southwest corner of the unit is located at UTM 391500E/3587000N, and the average elevation of the unit is 1274 m (Figure 1.3). Average slope on this portion of the alluvial fan ranges from less than one-half of a degree on the west to more than one and a half degrees as one approaches the mountains. This unit appears to be located almost precisely where the well-channeled drainages come off the fan and gradually dissipate on the basin floor. One deeply cut arroyo divides this survey unit into two parts. The arroyo is paralleled on both sides by many small, meandering drainage channels that either eventually disappear into the basin floor to the west or flow into the arroyo.

Vegetation and topography in Survey Unit 3 are similar to those of the basin floor except that the mesquite-covered coppice dunes are not as large, averaging about 1 m in height, and the intervening areas are better stabilized. Mesquite is the dominant shrub species, followed by snakeweed, saltbush, and sage. Some small, isolated areas contain well-developed grasslands, but these are infrequent.

Ten archeological sites were documented in Unit 3 during the Phase II survey; only three of them were discovered during Phase I. Two of these three large, multicomponent sites (LA 62124 and LA 62125) extend outside the Phase II survey area and thus were only partially surveyed. As can be seen in Figure 7.5, clustering of cultural material is very pronounced in this unit, and the sites as defined represent discrete clusters at a 10 m level of resolution. Surface materials are especially clustered in the southwest and northeast portions of the unit, and an area of more or less continuous distribution occurs north of the arroyo and west of LA 61126.

Chronological studies using both radiocarbon determinations and ceramic evidence indicate that sites within this unit were occupied from the Late Archaic period through the Doña Ana phase. Two of the multicomponent sites date to the Late Mesilla phase, while the third appears to have a strong Late Archaic component with a smaller Mesilla and Doña Ana phase occupation. One of the remaining seven sites is Mesilla phase, two are ceramic unknown, and four are lithic unknown. These chronological distinctions appear to have spatial correlates. With only one exception, the arroyo serves as a boundary between preceramic (or nonceramic) sites to the north and ceramic period sites to the south.

LA 62124 (WS 1124)

Location: UTM 391450E/3587208N (Figures 7.5, 7.6, and 7.7)
Size: ca. 86 by 96 m; 6484.2 sq m
Temporal/cultural affiliation: Multicomponent (Early to Late Mesilla)

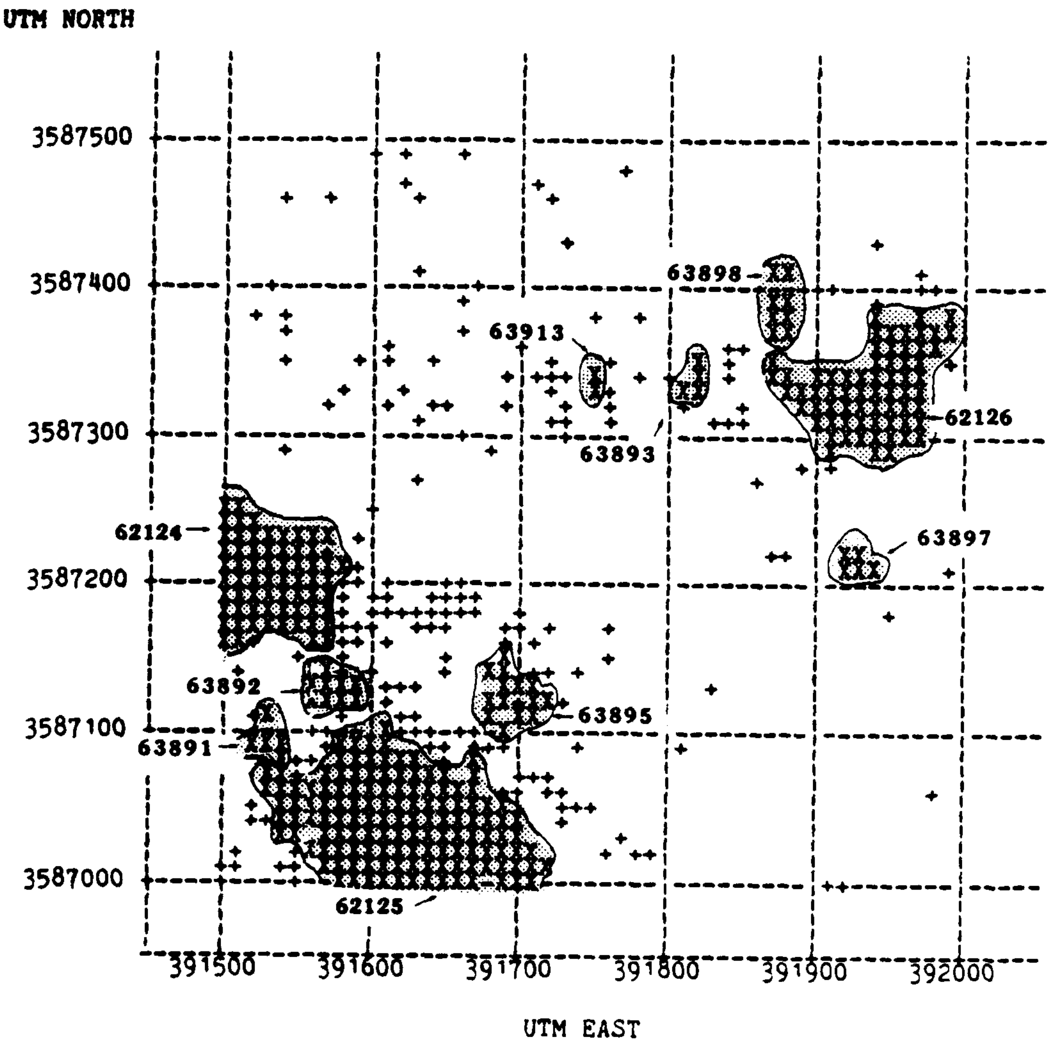


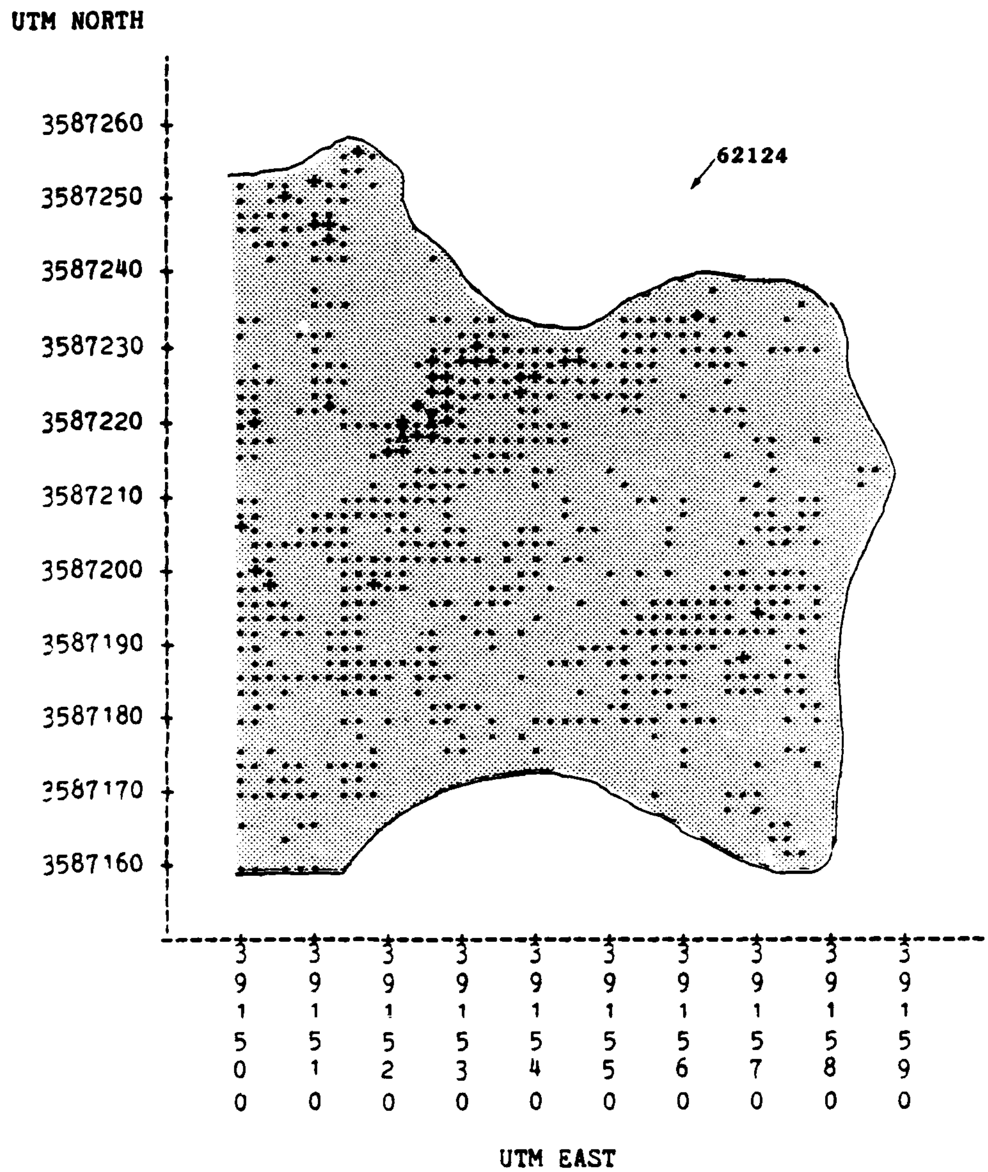
Figure 7.5. Phase II Survey Unit 3: Distribution of sites (X) and isolates (+)

LA 62124 is an extensive scatter of fire-cracked rock, lithics, and ceramics exposed in an stabilized area of low coppice dunes just south of the deeply channelled arroyo. The site is located along the western boundary of Survey Unit 3, and thus only a portion (ca. one-third) of the site was intensively surveyed.

More than 1700 fragments of fire-cracked rock were recorded on this site, yielding an overall density of 0.27 fragments per sq m (Tables 7.5 and 7.6). This material is not evenly distributed over the surface of the site; only 21 percent of the grids contained fire-cracked rock, and concentrations were recorded with as many as 45 fragments in a single recording unit. Three charcoal stains and nine discernible hearths were recorded, but did not contain sufficient charcoal for radiocarbon dating. The distribution of fire-cracked rock and other associated features is illustrated in Figure 7.7, where some very definite concentrations are obvious. These spatial patterns are also mirrored—with one major exception—by the distribution of all cultural materials illustrated in Figure 7.6. This exception is a major fire-cracked rock concentration located along the unit boundary between UTM 3587180 and 3587210N, which contains significantly less in the way of ceramics

Table 7.5. LA 62124 feature summary

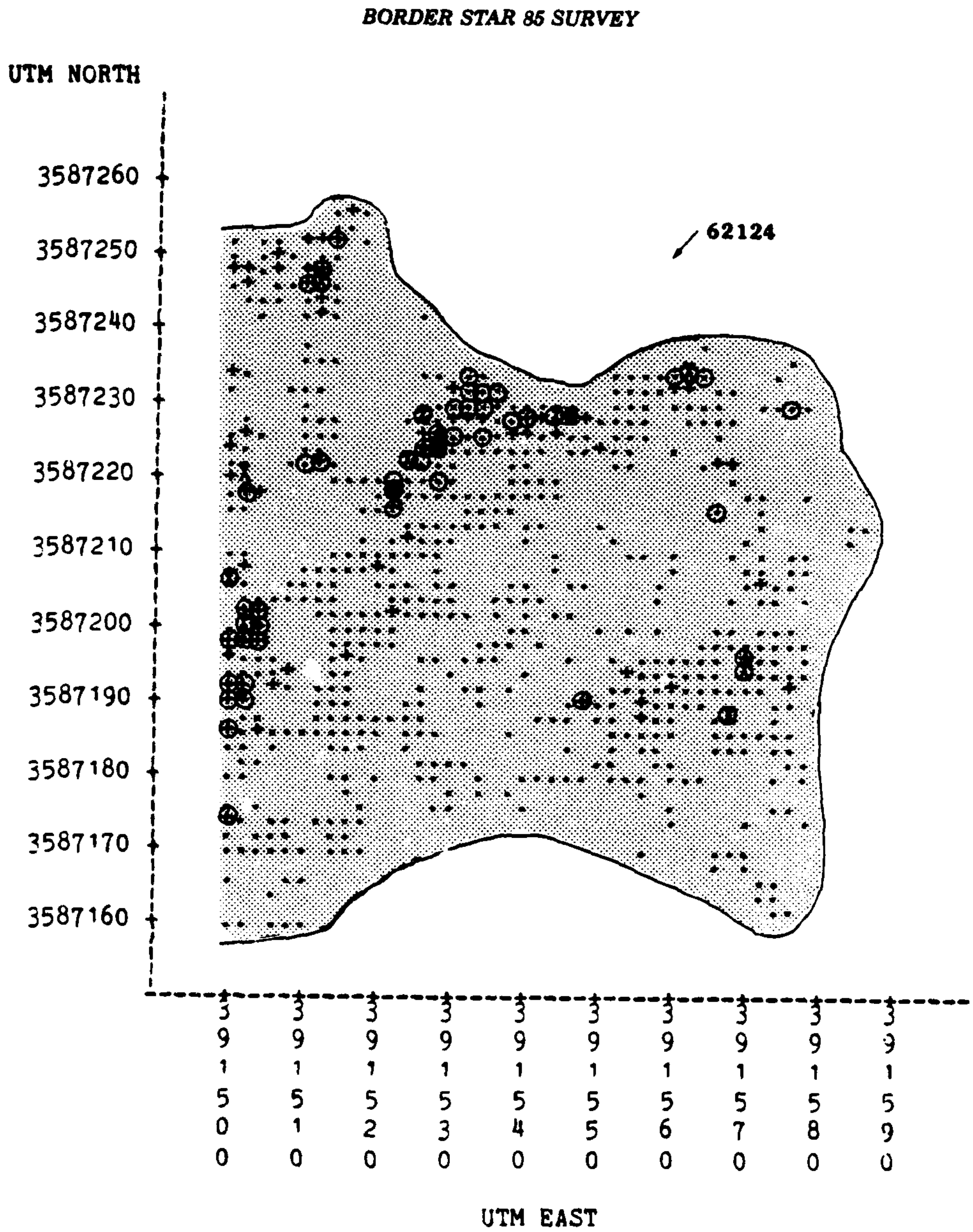
Feature Type	Grid Count	Feature Percentage
Bone	10	2.66
FCR Concentration	31	8.24
FCR Scatter	323	85.90
Hearth	9	2.39
Charcoal/Ash	3	0.80
Total	376	99.99



SYMBOL	TOTAL	SYMBOL	TOTAL
......	1.000 - 19.875	XXXXXX	57.625 - 95.375
++++++	19.875 - 57.625	000000	95.375 - 133.125

SYMBOL	TOTAL
■■■■■■	133.125 - 152.000

Figure 7.6. Phase II Survey Unit 3: Total artifact density at LA 62124



SYMBOL	FCRCT	SYMBOL	FCRCT
......	0.000 - 6.125	XXXXXX	18.375 - 30.625
++++++	6.125 - 18.375	⊕⊕⊕⊕⊕⊕	30.625 - 42.875

SYMBOL	FCRCT
■■■■■■	42.875 - 49.000
O	FEATURE

Figure 7.7. Phase II Survey Unit 3: Distribution of features and fire-cracked rock (FCR) densities at LA 62124

Table 7.6. LA 62124 fire-cracked rock statistics

Site Number	Size	Number of Grids	Grid Percent	Total FCR	Mean FCR	Max FCR	FCR Density
1124	6484	354	21.84	1759	4.97	45	0.27

and lithic artifacts than the other concentrations in this site. The presence of bone fragments in most of these concentrations strongly suggests that preserved midden deposits and undetected architectural features exist at LA 62124.

A total of 906 lithic artifacts were recorded on LA 62124. Almost 90 percent (808) is debitage; the remaining 10 percent of the lithic assemblage consists of cores, pounding implements, a variety of chipped stone tools, and fragmentary ground stone (Table 7.7).

As shown in Table 7.8, almost 78 percent of the debitage from LA 62124 is made of coarse-grained material types. The debitage assemblage also reflects an emphasis on relatively unrefined techniques or early stages of reduction—the former emphasis is probably related to the frequent use of coarse-grained lithic materials. More than 75 percent of the complete flakes exhibit cortical or single-facet platforms, and only 8.33 percent had ground, flaked, or otherwise prepared platforms (Table 7.9). Also, dorsal cortex class frequencies for the assemblage show a relatively high frequency (nearly 21 percent) of flakes with more than 10 percent cortex (Table 7.10). Average flake thickness for the sample of 342 complete flakes is 6.16 mm ($s = 4.31$)—also a relatively high figure characteristic of "less refined" reduction activities. Finally, most of the cores recorded on LA 62124 are specimens of coarse-grained material with few or no well-developed striking platforms (i.e., irregular cores in Table 7.7).

Chipped stone tools from LA 62124 consist of eight retouched flakes and pieces of angular debris, seven unifacial and three bifacial tools, and three projectile points. Although not easily placed in extant typologies, on the basis of general hafting morphology two of these points appear to be consistent with other points from the Early to Middle Archaic periods and the third with points from the Middle to Late Archaic periods. These three artifacts suggest the presence of an Archaic component, but recycling of these artifacts by later populations is also a distinct possibility. During the Phase I survey it was recognized that ceramic sites dated to the Formative period commonly contained Archaic projectile points.

The 47 ground stone artifacts recorded on LA 62124 include 21 mano fragments—most of which were one-handed—and 11 metates of various types, only one of which was complete (Table 7.7). The single complete metate has a grinding surface area of 165 sq cm.

Ceramics recorded on LA 62124 totaled 1278 sherds, almost 98 percent of which were nondiagnostic brownware body sherds (Table 7.11). The remaining 2 percent is made up of 22 El Paso Brown (rim) sherds, one sherd each of Mogollon Red-on-brown and El Paso Bichrome, and three

Table 7.7. LA 62124 lithic artifact inventory

Lithic Type	Count	Percentage of Total	Percentage of Type
Debitage			
Angular Debris	208	22.96	25.74
Flake	556	61.37	68.81
Biface Flake	32	3.53	3.96
Sharpen Flake	12	1.32	1.49
Subtotal	808	89.18	100.00
Cores			
Tested Rock	2	0.22	8.00
Irregular Core	19	2.10	76.00
Biface Core	2	0.22	8.00
"Blade" Core	2	0.22	8.00
Subtotal	25	2.76	100.00
Pounding Tools			
Hammer	3	0.33	75.00
Anvil	1	0.11	25.00
Subtotal	4	0.44	100.00
Chipped Stone Tools			
Retouched Angular Debris	1	0.11	4.76
Retouched Flake	7	0.77	33.33
Projectile Point	3	0.33	14.29
Biface	3	0.33	14.29
Uniface	7	0.77	33.33
Subtotal	21	2.31	100.00
Grinding Tools			
Unknown Ground Stone	15	1.66	31.91
Unknown Mano	8	0.88	17.02
One-hand Mano	13	1.43	27.66
Unknown Metate	8	0.88	17.02
Slab Metate	1	0.11	2.13
Basin Metate	1	0.11	2.13
Trough Metate	1	0.11	2.13
Subtotal	47	5.18	100.00
Other			
Other	1	0.11	100.00
Total	906	99.98	

Table 7.8. LA 62124 debitage material summary

Material Type	Count	Percentage of Total	Percentage of Type
Waxy Chert	173	19.09	21.41
Dull Chert	611	67.44	75.62
Chalcedony	3	0.33	0.37
Sil Wood	1	0.11	0.12
Quartzite	3	0.33	0.37
Obsidian	3	0.33	0.37
Basalt	2	0.22	0.25
Rhyolite	1	0.11	0.12
Sandstone	2	0.22	0.25
Granite	2	0.22	0.25
Volc Porphyry	1	0.11	0.12
Carbonates	5	0.55	0.62
Other Misc	1	0.11	0.12
Total	808	89.17	99.99

Table 7.9. LA 62124 complete flake platforms

Platform	Count	Percent
N/A	7	2.01
Collapsed	26	7.47
Cortical	86	24.71
Single Facet	176	50.57
Multi Facet	24	6.90
Prepared	29	8.33
Total	348	99.99

Table 7.10. Amount of dorsal cortex on complete flakes from LA 62124

Cortex	Count	Percent
None	238	68.39
1–10 Percent	37	10.63
11–30 Percent	20	5.75
31–80 Percent	29	8.33
81–100 Percent	24	6.90
Total	348	100.00

Table 7.11. LA 62124 ceramic assemblage data

Ceramic Type	Count	Percentage of Type
Unspecific Brown	1234	96.56
Plain Other Brown	17	1.33
Mogollon R/B	1	0.08
Unknown Mimbres B/W	3	0.23
El Paso Bichrome	1	0.08
El Paso Brown	22	1.72
Total	1278	100.00

of Mimbres Black-on-white that could not be placed into the more refined Mimbres style categories. Using strict presence/absence criteria, the diagnostics would suggest multicomponent status for the site, which would include occupation during the Late Mesilla and Doña Ana phases. When the relative frequencies of these types are taken into consideration, however, it would seem that a Late Mesilla occupation is more likely. This conclusion is supported by rim thickness measurements taken on 19 of the 22 El Paso Brown rims collected from the site. The mean rim thickness index or *rim sherd index* for all vessel forms of El Paso Brown sherds is 0.83 ($s = 0.10$) with a minimum of 0.67 and a maximum of 1.11. According to previous brownware rim studies in the Tularosa Basin (Carmichael 1983; West 1981), these figures are well within the range of documented Mesi''a phase assemblages.

Jars are the most common form in the ceramic assemblage, representing 58.33 percent of all rim sherds (Table 7.12). Within the El Paso Brown sherds, neckless jars predominate with 10 specimens (45.45 percent), followed by bowls (4 or 18.18 percent) and necked jars (3 or 13.64 percent).

LA 62125 (WS 1125)

Location: UTM 391629E/3587026N (Figures 7.5, 7.8, and 7.9)

Size: ca. 198 by 192 m; 29857.7 sq m

Temporal/cultural assignment: Multicomponent (Early to Late Mesilla; AD 150, AD 700, AD 1090)

This site consists of an extensive scatter of fire-cracked rock, lithics, and ceramics exposed in a very extensive area of closely spaced low coppice dunes. The site is located along the southern boundary of Survey Unit 3, and thus only about one-half of the total area as defined in Phase I was intensively surveyed.

Feature observations made during intensive survey of this site include fire-cracked rock counts in 369 grids, 3 hearth features, 15 charcoal stains, and 5 grids with bone (Table 7.13). Three charcoal stains yielded radiocarbon dates of 1800 ± 70 years BP (AD 150; Sample 11), 1250 ± 80 years BP (AD 700; Sample 7), and 860 ± 60 years BP (AD 1090; Sample 12), indicating occupation during the entire Mesilla phase and perhaps into the Doña Ana phase. As in the case of LA 62124, the presence of bone fragments along with the large and diverse assemblage of lithic and ceramic artifacts suggests that midden deposits and perhaps buried architectural features are present. Fire-cracked rock recorded during Phase II survey totaled 1063 fragments distributed among 369 grids (Table 7.14). Slightly less than

Table 7.12. LA 62124 vessel form data

Vessel Form	Count	Percentage of Form
Bowl	4	16.67
Indet	6	25.00
Jar	14	58.33
Total	24	100.00

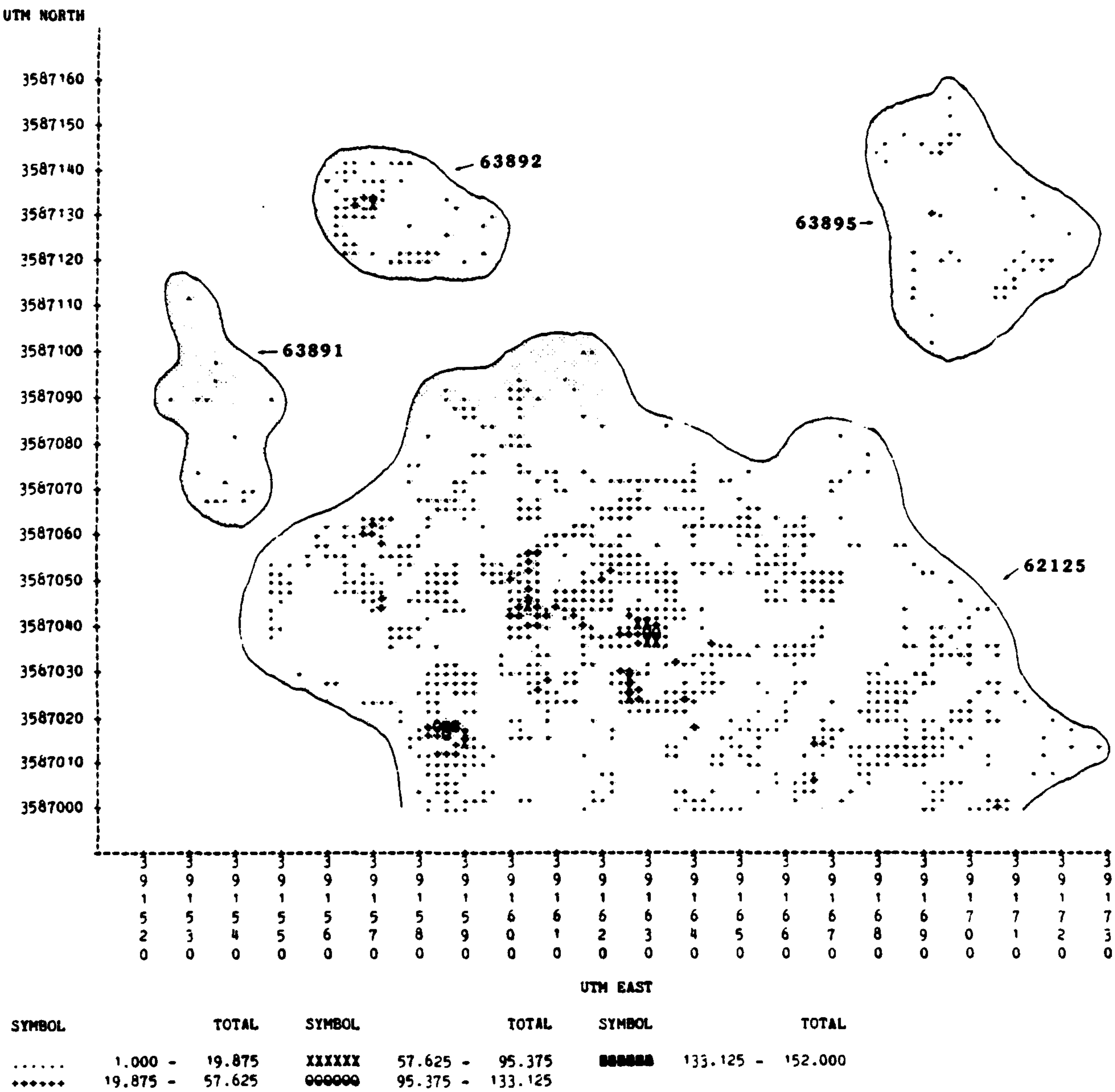


Figure 7.8. Phase II Survey Unit 3: Total artifact density at LA 62125, 63891, 63892, and 63895

Table 7.13. LA 62125 feature summary

Feature Type	Grid Count	Feature Percentage
Bone	5	1.28
FCR Concentration	4	1.02
FCR Scatter	365	93.11
Hearth	3	0.77
Charcoal/Ash	15	3.83
Total	392	100.01

5 percent of the recorded grids on the site contained fire-cracked rock.

The distribution of the features is illustrated in Figure 7.9, where a single dense concentration of features and debris exhibiting evidence of fire can be isolated near the center of the site. As the accompanying illustration of the total artifact distribution shows (Figure 7.8), this cluster is equally dense in terms of other items of material culture.

Lithic artifacts recorded on LA 62125 include 2562 pieces of debitage, 89 cores of various types, 9 hammerstones or

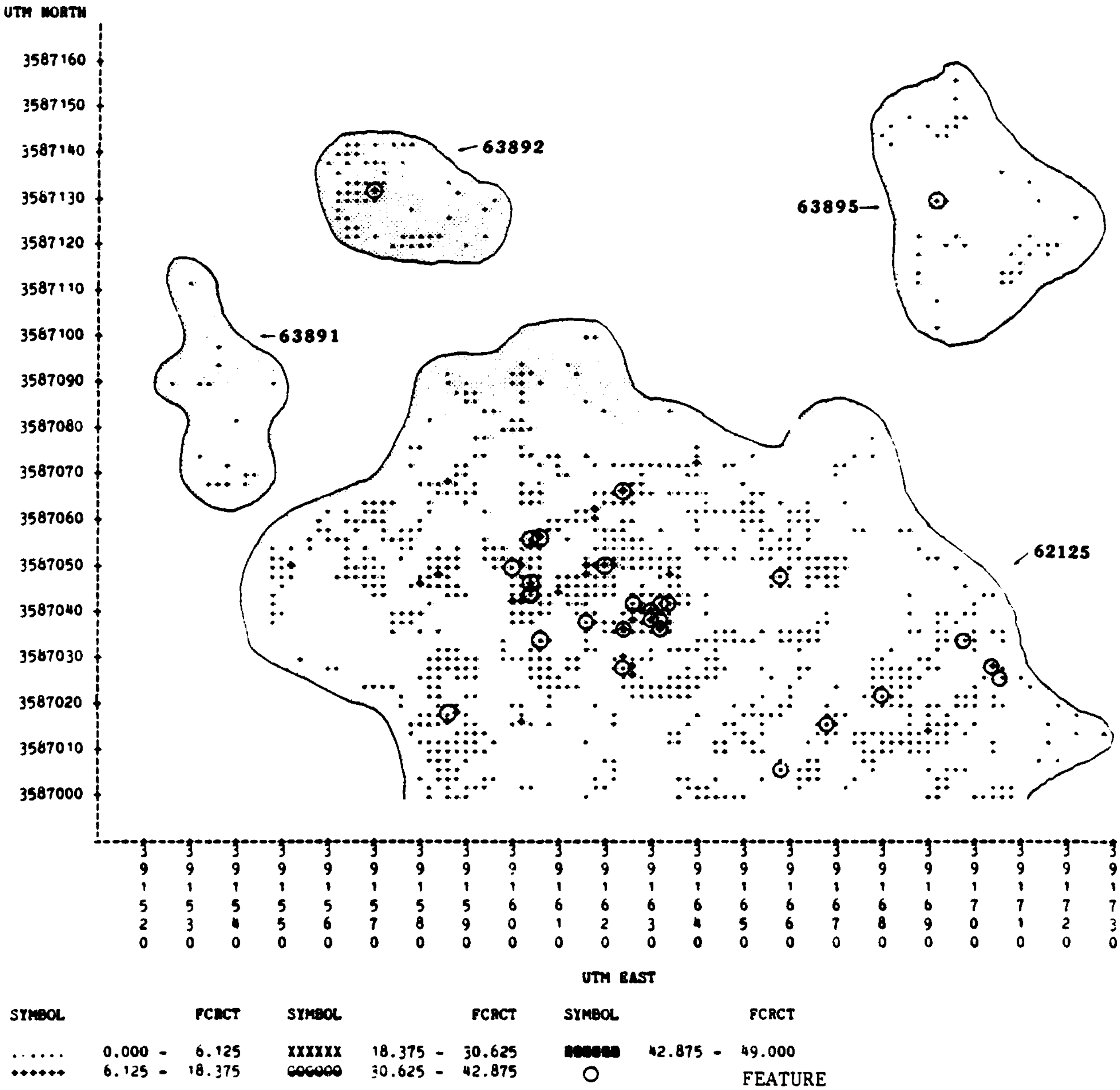


Figure 7.9. Phase II Survey Unit 3: Distribution of features and fire-cracked rock (FCR) densities at LA 62125, 63891, 63892, and 63895

mauls, 23 chipped stone tools, and 69 whole and fragmentary grinding implements (Table 7.15). Debitage constitutes the overwhelming majority of the lithic inventory (almost 93 percent of the total). Angular debris makes up more than 18 percent of the debitage—a fact that may relate to the relatively high proportion of coarse-grained material in this artifact group. Approximately 80 percent of the debitage and 86 percent of the cores consist of locally available dull chert (Table 7.16).

Striking platform statistics for the 1112 complete flakes in the assemblage suggest that reduction activities on LA 62125 were not very refined. Table 7.17 illustrates the predominance of cortical and single-facet platforms, which together account for almost 70 percent of the total. Prepared platforms, which are commonly associated with biface manufacture or resharpening, make up only 5.13 percent of the complete flakes. Average flake thickness for the assemblage also suggests that little refined reduction took place on the site (mean = 6.61 mm; n = 1106; s = 5.83). Dorsal cortex data do not seem to reflect any pronounced emphasis on early reduction stages as only 17 percent of the complete flakes have more than 10 percent cortex on their dorsal surfaces (Table 7.18).

Table 7.14. LA 62125 fire-cracked rock statistics

Site Number	Size	Number of Grids	Grid Percent	Total FCR	Mean FCR	Max FCR	FCR Density
1125	29858	369	4.94	1063	2.88	17	0.04

Table 7.15. LA 62125 lithic artifact inventory

Lithic Type	Count	Percentage of Total	Percentage of Type
Debitage			
Angular Debris	468	16.95	18.27
Flake	1855	67.19	72.40
Biface Flake	176	6.37	6.87
Sharpen Flake	63	2.28	2.46
Subtotal	2562	92.79	100.00
Cores			
Tested Rock	6	0.22	6.74
Irregular Core	61	2.21	68.54
Biface Core	11	0.40	12.36
"Blade" Core	11	0.40	12.36
Subtotal	89	3.23	100.00
Pounding Tools			
Hammer	9	0.33	100.00
Chipped Stone Tools			
Retouched Angular Debris	1	0.04	4.35
Retouched Flake	10	0.36	43.48
Projectile Point	4	0.14	17.39
Biface	3	0.11	13.04
Uniface	5	0.18	21.74
Subtotal	23	0.83	100.00
Grinding Tools			
Unknown Ground Stone	14	0.51	20.29
Unknown Mano	23	0.83	33.33
One-hand Mano	3	0.11	4.35
Two-hand Mano	1	0.04	1.45
Unknown Metate	15	0.54	21.74
Slab Metate	4	0.14	5.80
Basin Metate	8	0.29	11.59
Trough Metate	1	0.04	1.45
Subtotal	69	2.50	100.00
Other			
Manuport	5	0.18	55.56
Other	4	0.14	44.44
	9	0.32	100.00
Total	2761	100.00	

Table 7.16. LA 62125 lithic material summary

Material Type	Count	Percentage of Total	Percentage of Type
Debitage			
Waxy Chert	459	16.62	17.92
Dull Chert	2053	74.36	80.13
Chalcedony	10	0.36	0.39
Sil Wood	2	0.07	0.08
Quartzite	6	0.22	0.23
Obsidian	5	0.18	0.20
Basalt	4	0.14	0.16
Rhyolite	2	0.07	0.08
Sandstone	3	0.11	0.12
Granite	2	0.07	0.08
Volc Porphyry	3	0.11	0.12
Carbonates	8	0.29	0.31
Other Misc	5	0.18	0.21
Subtotal	2562	92.78	100.01
Cores			
Waxy Chert	8	0.29	8.99
Dull Chert	77	2.79	86.52
Chalcedony	1	0.04	1.12
Granite	1	0.04	1.12
Carbonates	2	0.07	2.25
Subtotal	89	3.23	100.00
Total	2651	96.01	

Table 7.17. LA 62125 complete flake platforms

Platform	Count	Percent
N/A	26	2.34
Collapsed	113	10.16
Cortical	252	22.66
Single Facet	519	46.67
Multi Facet	145	13.04
Prepared	57	5.13
Total	1112	100.00

Table 7.18. Amount of dorsal cortex on complete flakes from LA 62125

Cortex	Count	Percent
None	833	74.91
1–10 Percent	90	8.09
11–30 Percent	82	7.37
31–80 Percent	67	6.03
81–100 Percent	40	3.60
Total	1112	100.00

The majority of cores recorded on LA 62125 exhibit few or no well-developed striking platforms; these irregular specimens make up almost 69 percent of this artifact class (Table 7.15). Chipped stone tools include retouched debitage (11 artifacts), unifacial (5) and bifacial (3) tools, and projectile points. The four projectile points consist of Middle to Late Archaic types (Augustin and Shumla), an unknown arrow point (presumably post-Archaic), and an unidentified point fragment. The small arrow point supports the suspected Formative period date for LA 62125, and it is speculated that the Archaic specimens represent recycling by post-Archaic populations, although the presence of an Archaic component cannot be ruled out on the basis of data collected by Phase II survey.

Ground stone artifacts recorded on LA 62125 include 27 manos, 2 of which were complete and had an average grinding surface area of 45.22 sq cm ($s = 27.97$). Also recorded were 28 metate fragments. Both one- and two-handed manos are represented, and the metate fragments include examples of slab, basin, and trough types. A wide range of grinding activities is indicated.

Although diagnostic types constitute a mere 2.31 percent of the 3197 recorded sherds, ceramics recorded on LA 62125 appear to be consistent with the three radiocarbon dates for the site (Table 7.19). Early to Late Mesilla phase use of the site is indicated by the presence of San Francisco Red and Mimbres Black-on-white Style II (transitional), while later Doña Ana phase occupation may be indicated by the few painted El Paso Brownwares. El Paso Brown rim sherds collected during intensive survey support a Late Mesilla phase temporal placement; the mean rim thickness ratio is 0.86 ($n = 49$; $s = 0.18$) for all vessel forms.

Table 7.19. LA 62125 ceramic assemblage data

Ceramic Type	Count	Percentage of Type
Unspecific Brown	3080	96.34
Plain Other Brown	40	1.25
Santa Fe Red	3	0.09
Mimbres II	1	0.03
Unknown Mimbres B/W	8	0.25
El Paso Bichrome	1	0.03
El Paso Polychrome	1	0.03
El Paso Brown	60	1.88
Unknown	3	0.09
Total	3197	99.99

Table 7.20. LA 62125 vessel form data

Vessel Form	Count	Percentage of Form
Bowl	12	18.75
Indet	28	43.75
Jar	24	37.50
Total	64	100.00

Jar forms outnumber bowls by a factor of 2:1 (Table 7.20). Of the 35 collected El Paso Brown rims, 19 (54.29 percent) are neckless jar forms, 5 (14.29 percent) are from necked jars with direct or slightly flared rims, and 11 (31.43 percent) are bowl forms.

LA 62126 (WS 1126)

Location: UTM 391841E/3587340N (Figures 7.5, 7.10, 7.11)
Size: ca. 208 by 96 m; 15682.8 sq m
Temporal/cultural assignment: Multicomponent (Late Archaic-Mesilla-Doña Ana phase; 380 BC, AD 350, AD 1180)

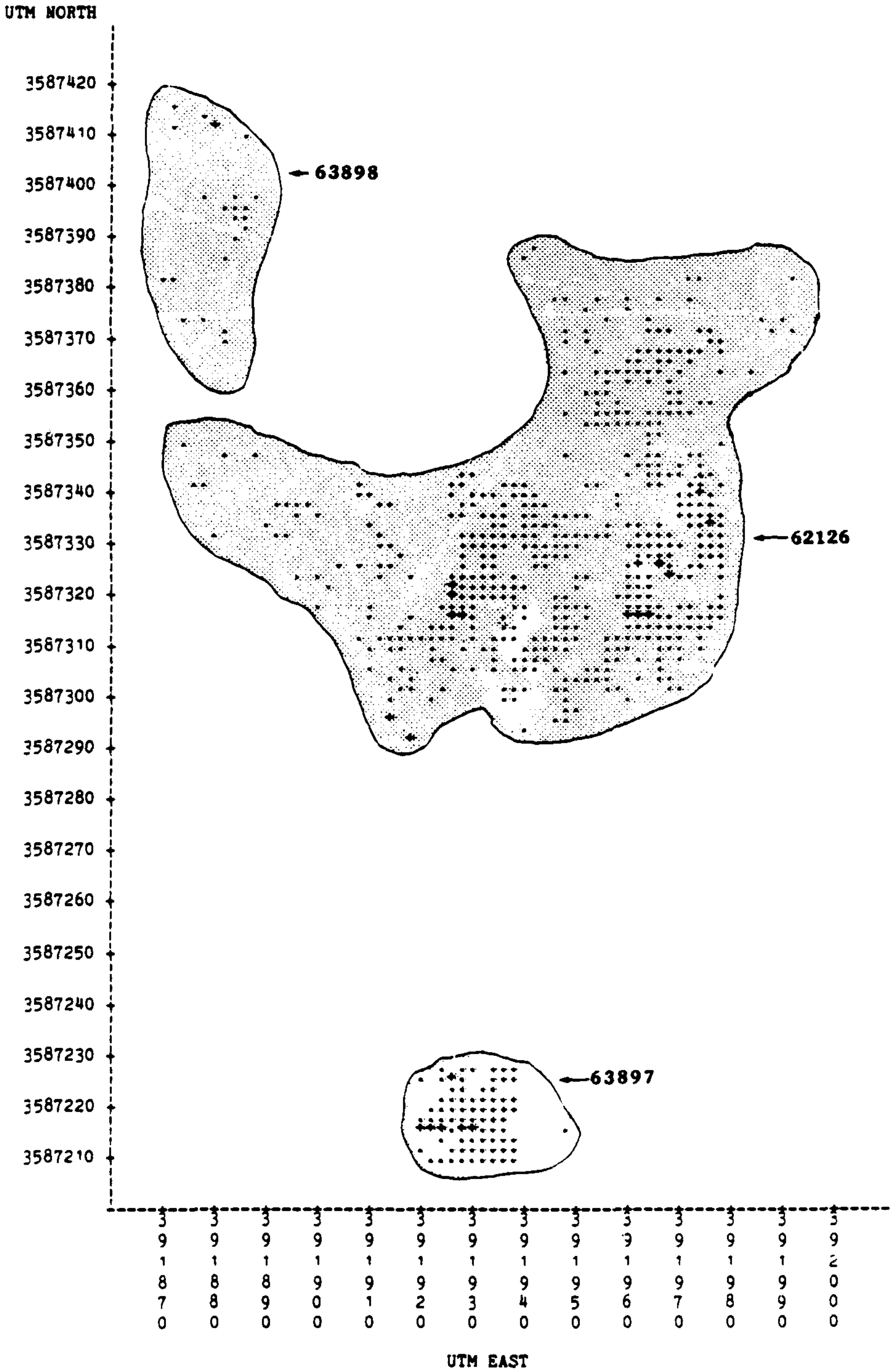
LA 62126 consists of an extensive scatter of fire-cracked rock and lithic artifacts with a small number of Unspecific Brown sherds. The site is located just north of the large arroyo in an area of widely spaced coppice dunes.

Features exhibiting the use of fire on LA 62126 include six exposed charcoal stains, all within 20 m of each other, and concentrations of fire-cracked rock in 13 grids (Table 7.21). Radiocarbon samples were obtained from three of the charcoal stains; determinations of 2330 ± 80 years BP (Sample 6; 380 BC), 1600 ± 80 years BP (Sample 2; AD 350), and 770 ± 70 years BP (Sample 4; AD 1180) indicate use of the site during the Late Archaic period and the Early Mesilla and Doña Ana phases.

Also recorded were 1217 fire-cracked rock fragments from 265 grids. The overall density of fire-cracked rock on LA 62126 is 0.08 fragments per sq m (Table 7.22), with a maximum of 40 fragments recorded in a single grid. Bone fragments were also noted in a single grid, suggesting the possibility of buried midden deposits. The distribution of

Table 7.21. LA 62126 feature summary

Feature Type	Grid Count	Feature Percentage
Bone	1	0.37
FCR Concentration	13	4.78
FCR Scatter	252	92.65
Charcoal/Ash	6	2.21
Total	272	100.01



SYMBOL		TOTAL	SYMBOL		TOTAL	SYMBOL		TOTAL
......	1.000 -	19.875	XXXXXX	57.625 -	95.375	■■■■■■	133.125 -	152.000
++++++	19.875 -	57.625	000000	95.375 -	133.125			

Figure 7.10. Phase II Survey Unit 3: Total artifact density at LA 62126, 63897, and 63898

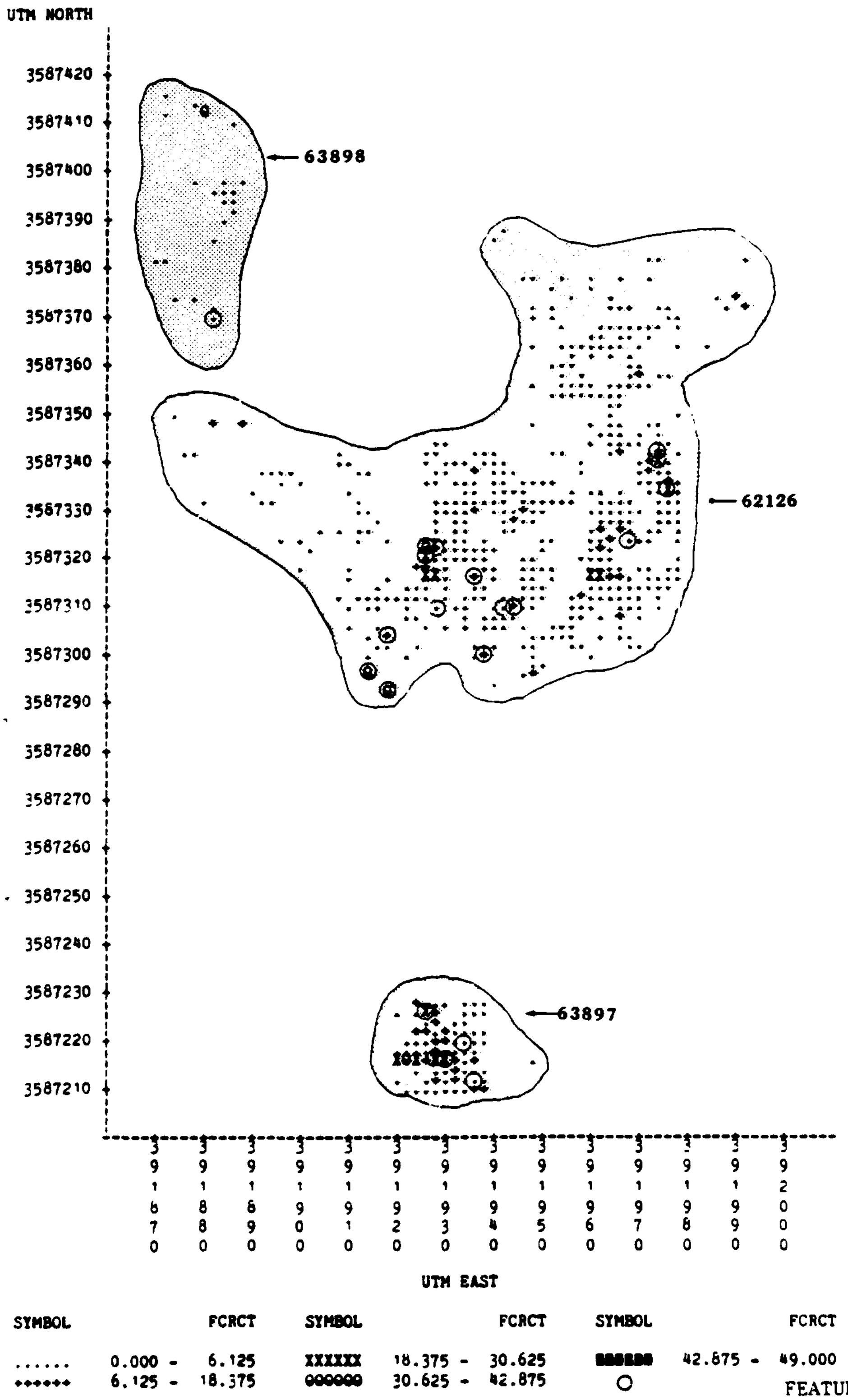


Figure 7.11. Phase II Survey Unit 3: Distribution of features and fire-cracked rock (FCR) densities at LA 62126, 63897, and 63898

Table 7.22. LA 62126 fire-cracked rock statistics

Site Number	Size	Number of Grids	Grid Percent	Total FCR	Mean FCR	Max FCR	FCR Density
1126	15683	265	6.76	1217	4.59	40	0.08

fire-cracked rock and related features is illustrated in Figure 7.11.

Recorded lithic artifacts from LA 62126 include 744 pieces of debitage, 36 cores, 3 hammerstones, 26 chipped stone tools, and 22 ground stone fragments (Table 7.23).

Debitage constitutes almost 90 percent of the lithic assemblage. Slightly more than 13 percent of the artifacts within that class are angular debris. Coarse-grained lithic materials dominate the debitage and core artifact categories at ca. 68 percent, although this figure is somewhat lower than those of other large sites within Unit 3 (Table 7.24). The definite tendency towards simple (i.e., cortical and single-facet) platforms is probably related to this emphasis on coarse materials (Table 7.25). Less than 6 percent of the complete flakes exhibit the prepared platform types associated with biface reduction and tool maintenance. Flake thickness statistics for 349 of the complete flakes also suggest an emphasis on less refined reduction (mean = 6.34 mm; $s = 5.40$); Again this greater average thickness is probably related to the high proportion of coarse materials in the assemblage. Dorsal cortex statistics (Table 7.26) are probably conditioned by other variables, such as

Table 7.23. LA 62126 lithic artifact inventory

Lithic Type	Count	Percentage of Total	Percentage of Type
Debitage			
Angular Debris	98	11.78	13.17
Flake	630	75.72	84.68
Biface Flake	4	0.48	0.54
Sharpen Flake	12	1.44	1.61
Subtotal	744	89.42	100.00
Cores			
Tested Rock	4	0.48	11.11
Irregular Core	20	2.40	55.56
Biface Core	2	0.24	5.56
"Blade" Core	10	1.20	27.78
Subtotal	36	4.32	100.01
Pounding Tools			
Hammer	3	0.36	100.00
Chipped Stone Tools			
Retouched Angular Debris	1	0.12	3.85
Retouched Flake	11	1.32	42.31
Projectile Point	3	0.36	11.54
Biface	4	0.48	15.38
Uniface	7	0.84	26.92
Subtotal	26	3.12	100.00
Grinding Tools			
Unknown Ground Stone	14	1.68	63.64
Unknown Mano	2	0.24	9.09
One-hand Mano	5	0.60	22.73
Unknown Metate	1	0.12	4.55
Subtotal	22	2.64	100.01
Other			
Other	1	0.12	100.00
Total	832	99.98	

Table 7.24. LA 62126 lithic material summary

Material Type	Count	Percentage of Total	Percentage of Type
Debitage			
Waxy Chert	233	28.00	31.32
Dull Chert	486	58.41	65.32
Chalcedony	6	0.72	0.81
Quartzite	1	0.12	0.13
Obsidian	1	0.12	0.13
Basalt	5	0.60	0.67
Rhyolite	5	0.60	0.67
Volc Porphyry	2	0.24	0.27
Carbonates	2	0.24	0.27
Other Misc	3	0.36	0.40
Subtotal	744	89.41	99.99
Cores			
Waxy Chert	12	1.44	33.33
Dull Chert	23	2.76	63.89
Other Misc	1	0.12	2.78
Subtotal	36	4.32	100.00
Total	780	93.73	

Table 7.25. LA 62126 complete flake platforms

Platform	Count	Percent
Collapsed	25	7.12
Cortical	54	15.38
Single Facet	240	68.38
Multi Facet	12	3.42
Prepared	20	5.70
Total	351	100.00

Table 7.26. Amount of dorsal cortex on complete flakes from LA 62126

Cortex	Count	Percent
None	282	80.34
1–10 Percent	23	6.55
11–30 Percent	16	4.56
31–80 Percent	10	2.85
81–100 Percent	20	5.70
Total	351	100.00

the size and shape of the raw material, which would affect the ratio of cortical surface to overall mass.

Cores recorded on LA 62126 are predominantly irregular in terms of platform orientation, although about a third of the specimens represent controlled bifacial and unidirectional reduction strategies. Other chipped stone tools include 3 hammerstones, 12 pieces of retouched debitage, 4 bifaces, 7 unifacial tools, and 3 projectile points. The projectile points consist of an untyped specimen and two that, although not placed in any typology, are consistent in their hafting technology and size with other Middle to Late Archaic types, such as Augustin. The paucity of ceramics on LA 62126, the earliest radiocarbon date (380 BC), and the morphology of these points suggest predominant use of the site during the Late Archaic period.

Grinding implements consist of 14 unidentifiable fragments, 3 manos (one of which was complete and had a grinding surface area of 109.2 sq cm), and a single metate fragment.

Consistent with radiocarbon dates of AD 350 and 1180, nine unspecific brownware sherds were recorded on LA 62126, indicating some use of the site during the Formative period.

LA 63891 (WS 2891)

Location: UTM 391537E/3587073N (Figures 7.5, 7.8, 7.9)
Size: ca. 22 by 30 m; 518.4 sq m
Temporal/cultural assignment: Ceramic unknown

This site consists of a sparse scatter of fire-cracked rock, lithics, and ceramics located just west of LA 62125. The remains of features evidencing the use of fire are represented by only six fragments of fire-cracked rock recorded in three grids. These few fragments showed no discernible configuration on the surface of the site. Overall fire-cracked rock density for this small site is 0.01 fragments per sq m.

The LA 63891 assemblage is small, numbering only 11 lithic artifacts and 23 sherds. Lithic artifacts include eight pieces of debitage—four each of dull and waxy chert varieties—and two sandstone ground stone fragments (one one-hand mano and one metate). Three of the five flakes were complete. The ceramic assemblage consists of 23 sherds of unspecific brownware. These sherds suggest that the site dates to the Formative period.

LA 63892 (WS 2892)

Location: UTM 391578E/3587131N (Figures 7.5, 7.8, 7.9)
Size: ca. 36 by 22 m; 622 sq m
Temporal/cultural assignment: Late Mesilla phase

This site is a scatter of fire-cracked rock, lithics, and ceramics located about halfway between LA 62124 and LA 62125 in an area of closely spaced coppice dunes. Fire-cracked rock was recorded in 20 grids within the boundaries of the site; maximum number of pieces per grid was five. The total fire-cracked rock count of 45 translates into a density figure of 0.07 fragments per sq m for the site. A single charcoal stain was recorded, but did not yield sufficient charcoal for dating purposes.

Lithic artifacts from LA 63892 include 33 identified items: 24 pieces of debitage (6 pieces of angular debris, 17 flakes, and 1 sharpening flake), 2 cores, a single hammerstone, and 6 fragmentary grinding implements. Only eight flakes were complete; of these, five had cortical or single-facet platforms and seven had less than 10 percent dorsal cortex. Debitage lithic materials are coarse-grained cherts (16 of dull chert), waxy chert (7 pieces), and carbonates (1 piece). Both of the cores in the assemblage (one tested rock and one irregular core) are of dull chert. Grinding implements are represented by fragments of four manos (one of them one-hand), one metate, and an unknown specimen.

The ceramic assemblage from LA 63892 is large in comparison to the lithics, with a total of 188 sherds; 185 of the sherds are unspecific brownware. Only 3 of the 188 sherds are temporally sensitive types: two Mimbres Black-on-white body sherds, which were too fragmentary or too eroded to place in a specific stylistic category, and a single El Paso Brown neckless jar rim with a rim thickness index of 0.71. These three sherds tentatively indicate a Late Mesilla phase use for LA 63892.

LA 63893 (WS 2893)

Location: UTM 391822E/3587347N
Size: ca. 12 by 22 m; 207.3 sq m
Temporal/cultural assignment: Lithic unknown

This small site consists of a sparse fire-cracked rock and lithic scatter. A total of 37 fire-cracked rock fragments were recorded in six grids yielding a density figure of 0.18 fragments per sq m. Maximum number of pieces per grid was eight. The fire-cracked rock has no configuration, and charcoal staining was not evident.

The only artifacts other than the fire-cracked rock recorded on LA 63893 are 19 pieces of debitage: 6 pieces of angular debris, 11 flakes (7 of which are complete), and 2 biface thinning flakes. Twelve of the pieces of debitage were of dull chert, and the remaining seven specimens were of fine-grained chert.

LA 63895 (WS 2895)

Location: UTM 391701E/3587129N (Figures 7.5, 7.8, and 7.9)
Size: ca. 42 by 54 m; 1781.3 sq m
Temporal/cultural assignment: Ceramic unknown

This site consists of a surface scatter of fire-cracked rock, lithics, and ceramics located in an area of low coppice dunes. The site has been bisected by a dirt road, but no buried deposits were noted along the embankment. The remains of one or more features are represented by 17 pieces of scattered fire-cracked rock recorded in 12 grids; a maximum of 3 pieces per grid was recorded. The density of this debris is very low (0.01 fragments per sq m). Charcoal staining was noted in one grid, though it was insufficient for dating purposes.

Lithic artifacts recorded on LA 63895 consist of 68 pieces of debitage, 3 irregular cores, a single nondiagnostic projectile point, and 2 ground stone fragments (one mano and one metate).

Almost 92 percent of the lithic assemblage recorded on LA 63895 consist of debitage: 14 pieces of angular debris, 50 flakes, and 4 biface flakes. The proportion of coarse-grained raw material types is high (83.82 percent), with the locally available dull chert dominating the debitage collection (Table 7.27). Rather large, simple flakes are the most common type of debitage. As illustrated in Table 7.28, flakes with single-facet or cortical platforms are most common with a combined percentage of 81.48. Size statistics for 26 complete flakes show a tendency for large flakes with a mean thickness of 6.31 mm ($s = 4.54$). Although almost 90 percent of the flakes exhibited less than 10 percent dorsal cortex (Table 7.29), the fact that almost 30 percent had cortical platforms would suggest that early stages of reduction are well represented.

A total of 47 plain brownware sherds were recorded during Phase II survey—44 Unspecific Brown, 2 Plain Other Brown, and 1 El Paso Brown. None of these sherds was useful in determining the age of LA 63895. The single El Paso Brown rim sherd collected was too small for computing a rim thickness ratio. In any case, the utility of a single ratio for dating purposes is questionable.

LA 63897 (WS 2897)

Location: UTM 391934E/3587219N (Figures 7.5, 7.10, 7.11)
Size: ca. 28 by 18 m; 395.8 sq m
Temporal/cultural assignment: Lithic unknown

LA 63897 consists of a relatively dense scatter of fire-cracked rock and lithic artifacts located just south of the large arroyo in a stabilized area surrounded by low coppice dunes. The site boundaries are well defined by the distribution of 396 pieces of fire-cracked rock (Figure 7.11). Fire-using features are well represented; 77 of the grids contained fire-cracked rock, some with as many as 40 fragments. The fire-cracked rock density for this site is high (1.20 fragments per sq m). Two grids also contained charcoal stains; however, they did not yield enough charcoal to allow radiocarbon determinations.

The LA 63897 lithic assemblage includes 31 pieces of debitage, 4 cores (3 irregular and 1 biface), a single unidentified projectile point, and 2 one-handed manos—one was fragmentary but one was complete and had a total grinding surface area of ca. 90 sq cm.

More than 81 percent of this assemblage is debitage: 11 pieces of angular debris, 19 flakes, and 1 biface flake. As Table 7.30 illustrates, coarse-grained material types such as dull cherts and carbonates are most common, accounting for more than 70 percent of the total debitage and all of the cores.

Table 7.27. LA 63895 debitage material summary

Material Type	Count	Percentage of Total	Percentage of Type
Waxy Chert	11	14.86	16.18
Dull Chert	53	71.62	77.94
Quartzite	2	2.70	2.94
Carbonates	2	2.70	2.94
Total	68	91.88	100.00

Table 7.28. LA 63895 complete flake platforms

Platform	Count	Percent
N/A	1	3.70
Collapsed	3	11.11
Cortical	8	29.63
Single Facet	14	51.85
Multi Facet	1	3.70
Total	27	99.99

Table 7.29. Amount of dorsal cortex on complete flakes from LA 63895

Cortex	Count	Percent
None	21	77.78
1–10 Percent	3	11.11
11–30 Percent	1	3.70
81–100 Percent	2	7.41
Total	27	100.00

Table 7.30. LA 63897 lithic material summary

Material Type	Count	Percentage of Total	Percentage of Type
Debitage			
Waxy Chert	9	23.68	29.03
Dull Chert	21	55.26	67.64
Carbonates	1	2.63	3.23
Subtotal	31	81.57	100.00
Cores			
Dull Chert	4	10.53	100.00
Total	35	92.10	

Given the high proportion of coarse materials in this assemblage, it is not surprising that the average flake thickness for complete specimens is quite high (mean = 8.40 mm; n = 15; $s = 4.73$) and that prepared platform types represent only 6.67 percent of the total (Table 7.31). Heavy-handed and early flake removals are indicated. Four of the 15 complete flakes also have appreciable amounts (>10 percent) of dorsal cortex (Table 7.32) and cortical platforms were recorded on 6 of the artifacts.

LA 63898 (WS 2898)

Location: UTM 391879E/3587393N (Figures 7.5, 7.10, 7.11)
Size: ca. 18 by 46 m; 650.3 sq m
Temporal/cultural assignment: Lithic unknown

This site consists of a scatter of fire-cracked rock and lithics located in a narrow stabilized area between a number of small coppice dunes. Although 45 fragments were recorded in three grids, the overall density of fire-cracked rock for the site is only 0.07 fragments per sq m. One of the grids contained 35 pieces. These remains probably represent a deflated hearth or roasting pit as no charcoal staining was noted.

The lithic assemblage from LA 63898 consists of 30 pieces of debitage (5 pieces of angular debris and 25 flakes), a spokeshave, a projectile point of unknown age or cultural affiliation, a one-hand mano, and 4 metate fragments.

In contrast to most sites in Unit 3, a relatively large percentage of the debitage from LA 63898 is of fine-grained material: 13 pieces are made of waxy chert, 16 of dull chert, and 1 of basalt. Although there are only 9 complete flakes, 6 had single-facet platforms, 2 had cortical platforms, and 1 had a collapsed platform. All 9 flakes had less than 10 percent dorsal cortex (8 had none), and they averaged 4.67 mm in thickness (n = 9; $s = 2.92$). Prepared platform types, which might be expected to result from such activities as biface manufacture and maintenance, are absent.

Table 7.31. LA 63897 complete flake platforms

Platform	Count	Percent
Collapsed	2	13.33
Cortical	6	40.00
Single Facet	3	20.00
Multi Facet	3	20.00
Prepared	1	6.67
Total	15	100.00

Table 7.32. Amount of dorsal cortex on complete flakes from LA 63897

Cortex	Count	Percent
None	9	60.00
1–10 Percent	2	13.33
11–30 Percent	2	13.33
31–80 Percent	1	6.67
81–100 Percent	1	6.67
Total	15	100.00

LA 63913 (WS 2913)

Location: UTM 391753E/3587338N (Figure 5.5)
Size: ca. 6 by 4 m; 18.8 sq m
Temporal/cultural assignment: Lithic unknown

LA 63913 is a very small scatter of fire-cracked rock and lithics exposed within a small stabilized area surrounded by low coppice dunes. The entire assemblage consists of 10 items: 6 fragments of fire-cracked rock, 3 pieces of chert debitage (2 pieces of angular debris and 1 complete flake), and a fragment of a sandstone basin metate. Two grids each contained three of the pieces of fire-cracked rock, yielding an overall site density of 0.32 fragments per sq m.

Sites in Survey Unit 4

Survey Unit 4 is located on the upper slope of the alluvial fan immediately west of the Jarilla Mountains; the southwest corner of the 500 by 500 m unit within which Survey Unit 4 is located is at UTM 394000E/3594000N (Figure 1.3). This survey unit differs from the other Phase II units in that intensive survey was conducted within an area of 100 by 100 m within the total 500 by 500 m area chosen on the basis of cluster analysis results. The southwest corner of the actual area surveyed is located at UTM 394286E/3594000N.

This unit lies on a broad alluvial fan less than 1 km from the base of the steep mountain slopes north and west of a major pass through the Jarillas (Monte Carlo Gap). The slope of the fan within Unit 4 ranges from 1.5 to 3.0 degrees, and drainage channels, which trend generally to the southwest, are well developed and cut as deep as 1 m in some arroyos. In general, areas between the gradually converging drainages are similar to many parts of the basin floor, with low, mesquite-topped coppice dunes interspersed with blowouts and sparse but stabilized grasslands. Dominant shrub species within the unit consist of mesquite, yucca, saltbush, and sand sage. Average elevation of the unit is 1274 m.

The survey unit lies entirely within a single archeological site—LA 63490. This site covers more than 37 ha and represents the most concentrated area of archeological material encountered during Phase I survey. The site is in reality a cluster of many closely spaced and perhaps overlapping sites that appear to have been occupied serially throughout the Formative period. This site cluster contains a considerable number of well-defined middens with large numbers of artifacts and features separated by less dense but continuous scatters of fire-cracked rock and sheet trash. Although very few architectural features were recorded during Phase I survey, it is believed that a more intensive and systematic survey of this site, along with test excavations, would reveal many more.

Table 7.33. LA 63490 artifact assemblage

Artifact Class	Number Recorded	Density per sq m
Ceramics	3739	0.37
Lithics	1745	0.17
FCR	253	0.03
Total	5737	0.57

Table 7.34. LA 63490 feature summary

Feature Type	Grid Count	Feature Percentage
Bone	7	5.93
FCR Scatter	110	93.22
Charcoal/Ash	1	0.85
Total	118	100.00

Phase II survey has focused on a 1 ha-area near the southern edge of LA 63490. The 100 by 100 m unit was originally centered on a very dense midden within the site, but when it became apparent that intensive documentation of this feature would compromise its integrity, the location of the unit was moved to a less dense and less fragile portion of the site. The material recorded in this unit is associated with a series of middens and at least one pithouse, which was defined by auger tests and lies to the north of the unit. These features are believed to date to the Late Mesilla and/or Doña Ana phases based on ceramic evidence. The following description of LA 63490 refers only to the 10,000 sq m area surveyed during Phase II.

LA 63490 (WS 2490)

Location: UTM 394920E/3594450N (Figures 7.12 and 7.13)

Size: 100 by 100 m; 10,000 sq m

Temporal/cultural assignment: Multicomponent (Late Mesilla-Doña Ana)

As seen from intensive surface survey, the internal structure of this portion of LA 63490 is complex. From an analytical point of view it is made even more so by the sheer magnitude of cultural material and by the effects of very active erosional processes on that material. Nearly 5500 items of material culture—exclusive of fire-cracked rock—were recorded in Unit 4 (Tables 7.33, 7.34, and 7.35).

The cultural material is not distributed uniformly over the surface of the site. Although coppice dunes create a series of artificial density "depressions," the artifacts occur in several fairly discrete, very dense clusters (up to 52 items per sq m) separated by wide areas of lower density (fewer than eight items per sq m; Figure 7.12). In some cases these clusters may represent partially disturbed borrow pit middens, as described by Marshall (1973) and Carmichael (1983:113), and the intervening areas of sheet trash appear to be materials eroding from these features. As Figure 7.13 suggests, the distribution of fire-cracked rock provides only very general clues to the spatial patterning of all materials shown in Figure 7.12. The seven grids with bone identified on the fire-cracked rock density map do, however, correspond with the areas thought to be middens. The presence of bone fragments on the surface at these locations also suggests that intact deposits remain undisturbed.

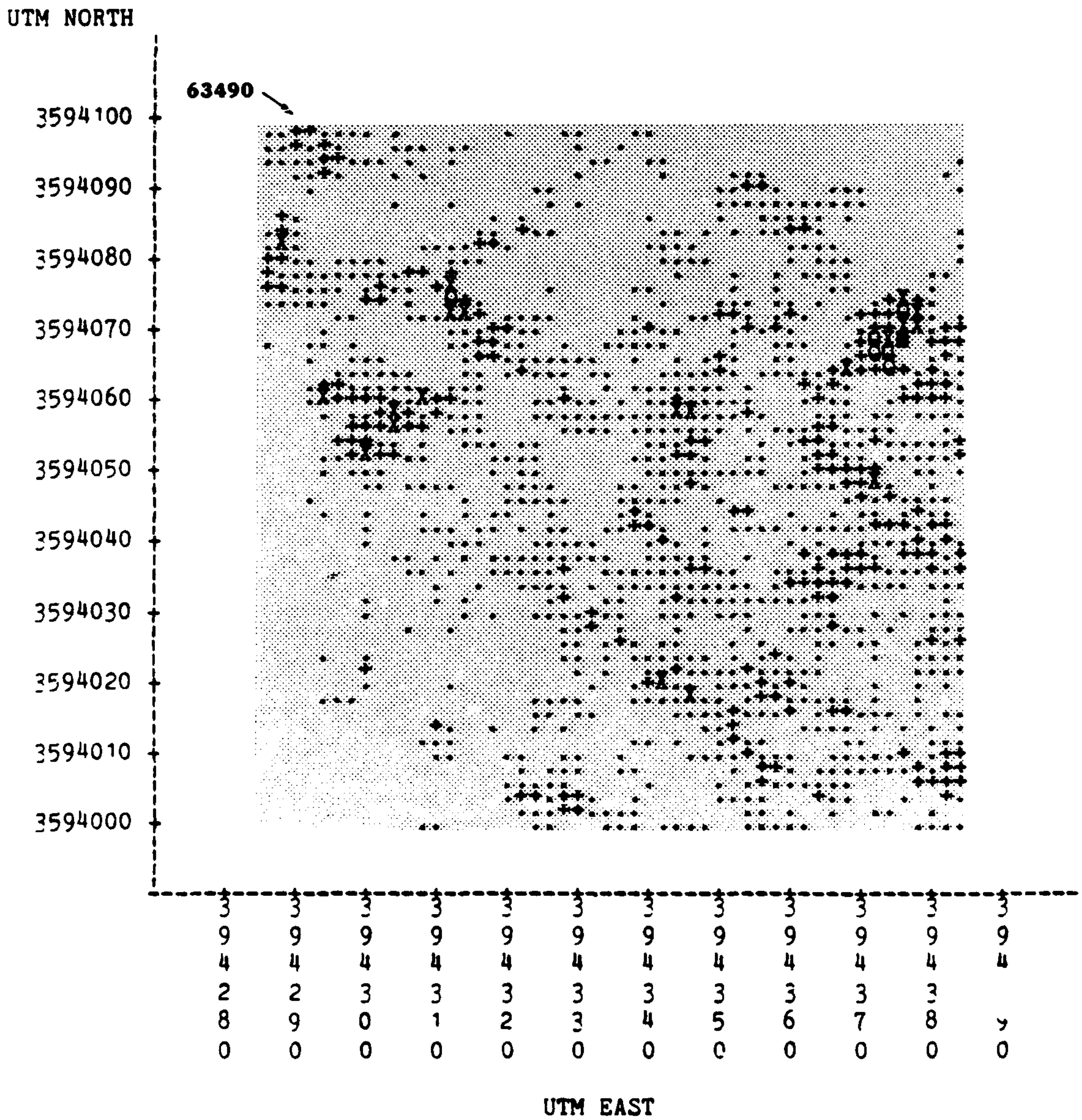
Lithic artifacts recorded on LA 63490 are shown in Table 7.36. As Table 7.37 illustrates, dull cherts and other coarse-grained materials dominate the debitage and core assemblages. The proportion of coarse materials is nearly identical for these two artifact groups. Since dull chert is readily available as a raw material on the mountain flanks and the alluvial fan upon which LA 63490 is situated, this high proportion is not at all surprising.

Reduction activities contributing to the LA 63490 debitage and core assemblages seem to be consistent with the constraints imposed by coarse-grained raw materials. A total of 908 flakes or 57.80 percent are complete. Platform statistics for this group (Table 7.38) suggest that reduction activities concentrated on somewhat expedient flake production; more than 83 percent exhibited simple cortical or single-facet platform types. Prepared platforms constitute a mere 2.31 percent of the complete flakes. The fact that the flakes are quite thick also supports this inference (mean = 7.56 mm; $s = 5.31$). The relatively high percentage of flakes with more than 10 percent dorsal cortex may reflect an emphasis on early stages of reduction (Table 7.39). Almost three-quarters of the cores recorded are irregular forms that show little maintenance or preparation of platform surfaces—a fact consistent with an expedient reduction strategy. Raw material shape and size as well as fracture properties are also conditioning factors.

Pounding implements are relatively numerous at LA 63490; most of the 22 specimens were well-battered pieces of dull chert (77.27 percent) and other coarse materials (18.18 percent), such as rhyolite and granite. These artifacts were coded as hammerstones during the survey, but many or most may be recycled cores or hammers that were used to create and maintain tools. Although the lithic coding system was not designed to record these characteristics, it was observed that many large flakes of coarse-grained material types exhibited extremely battered dorsal surfaces and platforms. It is quite likely that many, if not most, of

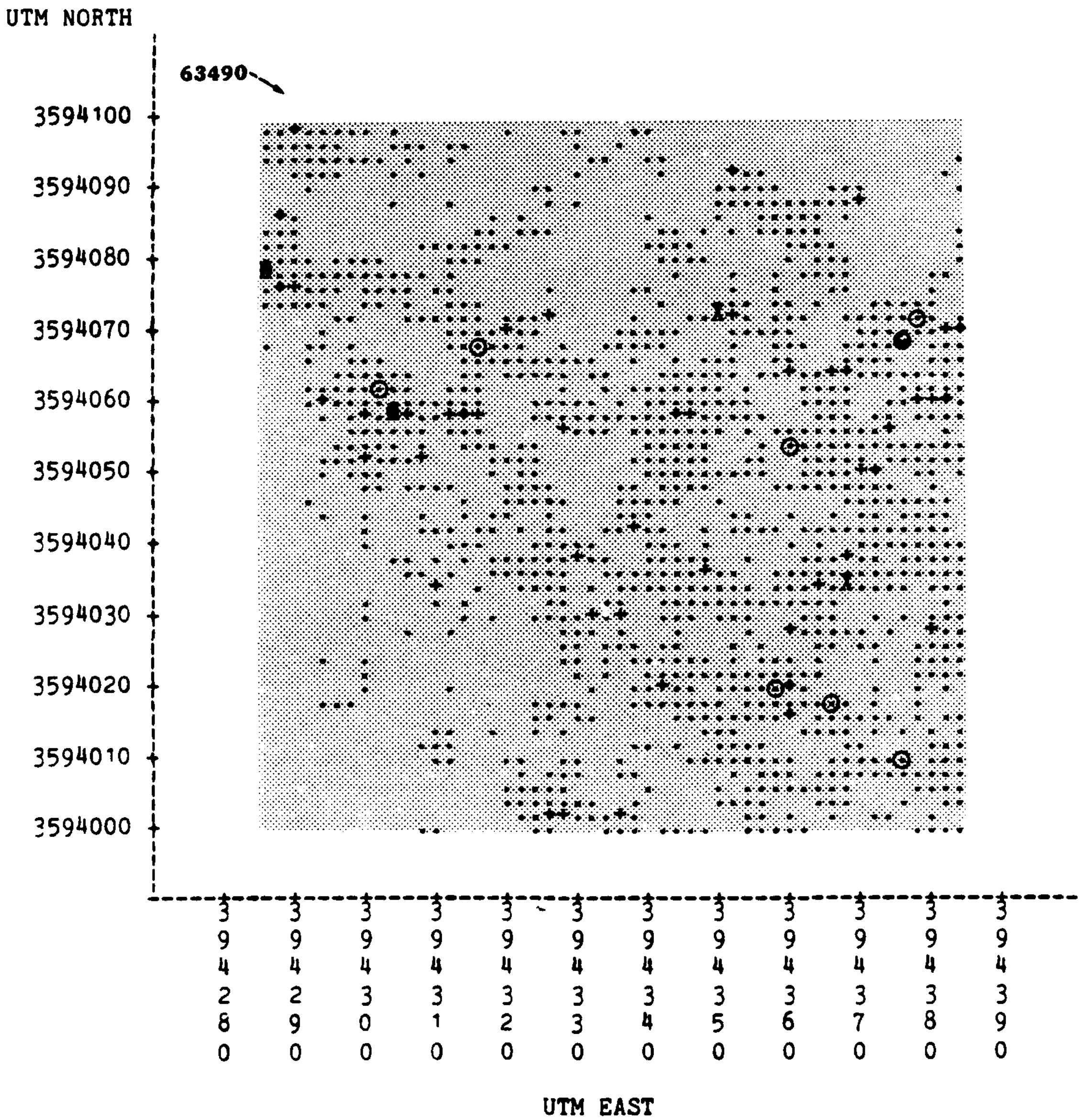
Table 7.35. LA 63490 fire-cracked rock statistics

Site Number	Size	Number of Grids	Grid Percent	Total FCR	Mean FCR	Max FCR	FCR Density
2490	10000	110	4.40	253	2.30	15	0.03



SYMBOL		TOTAL	SYMBOL		TOTAL	SYMBOL		TOTAL
......	1.000 -	7.375	XXXXXX	20.125 -	32.875	■■■■■■	45.625 -	52.000
++++++	7.375 -	20.125	000000	32.875 -	45.625			

Figure 7.12. Phase II Survey Unit 4: Total artifact density at LA 63490



SYMBOL		FCRCT	SYMBOL		FCRCT	SYMBOL		FCRCT
......	0.000 -	1.875	XXXXXX	5.625 -	9.375	■■■■■■	13.125 -	15.000
++++++	1.875 -	5.625	000000	9.375 -	13.125	O		FEATURE

Figure 7.13. Phase II Survey Unit 4: Distribution of features and fire-cracked rock (FCR) densities at LA 63490

Table 7.36. LA 63490 lithic artifact inventory

Lithic Type	Count	Percentage of Total	Percentage of Type
Debitage			
Angular Debris	251	14.38	15.98
Flake	1300	74.50	82.75
Biface Flake	14	0.80	0.89
Sharpen Flake	6	0.34	0.38
Subtotal	1571	90.02	100.00
Cores			
Tested Rock	5	0.29	6.41
Irregular Core	53	3.04	67.95
Biface Core	7	0.40	8.97
"Blade" Core	13	0.74	16.67
Subtotal	78	4.47	100.00
Pounding Tools			
Hammer	22	1.26	100.00
Chipped Stone Tools			
Retouched Angular Debris	3	0.17	15.79
Retouched Flake	8	0.46	42.11
Projectile Point	5	0.29	26.32
Biface	1	0.06	5.26
Uniface	2	0.11	10.53
Subtotal	19	1.09	100.00
Grinding Tools			
Unknown Ground Stone	24	1.38	47.06
Unknown Mano	16	0.92	31.37
One-hand Mano	1	0.06	1.96
Unknown Metate	7	0.40	13.73
Slab Metate	1	0.06	1.96
Basin Metate	2	0.11	3.92
Subtotal	51	2.93	100.00
Other			
Manuport	3	0.17	75.00
Other	1	0.06	25.00
	4	0.23	100.00
Total	1745	100.00	

Table 7.37. LA 63490 lithic material summary

Material Type	Count	Percentage of Total	Percentage of Type
Debitage			
Waxy Chert	102	5.58	6.49
Dull Chert	1397	80.06	88.92
Chalcedony	7	0.40	0.45
Sil Wood	1	0.06	0.06
Quartzite	10	0.57	0.64
Obsidian	1	0.06	0.06
Basalt	6	0.34	0.38
Rhyolite	7	0.40	0.45
Sandstone	5	0.29	0.32
Granite	7	0.40	0.45
Volc Porphyry	3	0.17	0.19
Carbonate	22	1.26	1.40
Other Misc	0	0.17	0.19
Subtotal	1571	90.03	100.00
Cores			
Waxy Chert	4	0.23	5.13
Dull Chert	71	4.07	91.03
Obsidian	1	0.06	1.28
Sandstone	1	0.06	1.28
Carbonates	1	0.06	1.28
Subtotal	78	4.48	100.00
Total	1649	94.51	

Table 7.38. LA 63490 complete flake platforms

Platform	Count	Percent
N/A	25	2.75
Collapsed	70	7.71
Cortical	239	26.32
Single Facet	522	57.49
Multi Facet	31	3.41
Prepared	21	2.31
Total	908	99.99

Table 7.39. Amount of dorsal cortex on complete flakes from LA 63490

Cortex	Count	Percent
None	564	62.11
1–10 Percent	119	13.11
11–30 Percent	95	10.46
31–80 Percent	79	8.70
81–100 Percent	51	5.62
Total	908	100.00

Table 7.40. LA 63490 diagnostic projectile points

Point Type	Material	Period
Ellis/Carr'n cvx	Waxy Chert	Late Archaic
Martindale	Waxy Chert	Middle Archaic
Jay	Waxy Chert	Early Archaic
Jay	Obsidian	Early Archaic
Unknown	Waxy Chert	Unknown

Table 7.41. LA 63490 ceramic assemblage data

Ceramic Type	Count	Percentage of Type
Unspecific Brown	3552	95.00
Plain Other Brown	68	1.82
Mimbres I	3	0.08
Mimbres II	4	0.11
Mimbres III	4	0.11
Unknown Mimbres B/W	19	0.51
El Paso Bichrome	21	0.56
El Paso Polychrome	27	0.72
Chupadero B/W	8	0.21
El Paso Brown	33	0.88
Total	3739	100.00

these hammerstones (and perhaps some portion of the irregular cores) are actually mauls.

Chipped stone tools make up only 1 percent of the LA 63490 lithic assemblage, and the majority of these artifacts consist of retouched debitage. The remainder of the items in this group are two unifacial tools, one biface, and five projectile points. As is common in most of the Border Star 85 Formative period sites, the points are largely Archaic types (Table 7.40).

Ceramics were by far the most numerous artifacts recorded on LA 63490 (Table 7.41). A total of 3739 ceramics were recorded within the 10,000 sq m survey unit, yielding an average ceramic density for the site of 0.37 sherds per sq m. The variety of ceramic types present on LA 63490 is typical of a very late Mesilla or Doña Ana phase assemblage as described by Carmichael (1985:45–49), Whalen (1980:34), and others. Almost 97 percent of the sherds are nondiagnostic. The rim thickness indices (Table 7.42) are also similar to Carmichael's figures for the Doña Ana or Transitional Pueblo phase (1983:81; 1985:47).

Table 7.43. LA 63490 vessel form data

Vessel Form	Count	Percentage of Form
Bowl	10	21.28
Indet	13	27.66
Jar	24	51.06
Total	47	100.00

In the LA 63490 assemblage jars outnumber bowl forms by a factor of 2.4:1 (Table 7.43). As is usually the case, all of the collected Mimbres rim sherds were from bowls. Within the El Paso Brownwares, jars are six times more frequent than bowls; the most common forms are jars without necks (El Paso Brown) and necked jars with direct or flared rims (the painted El Paso types).

Sites in Survey Unit 5

Survey Unit 5 is located on the basin floor immediately east of Unit 2; the southwest corner of the unit is at UTM 384000E/3590500N (Figure 1.3). Unit 5 differs from its neighboring survey parcel in the extent and severity of erosion. In general, coppice dunes in this unit are much larger and support less stabilizing vegetation than those of Unit 2, and a greater proportion of the surface is considered erosionally active. Average elevation of the unit is 1225 m.

As revealed by intensive survey, the distribution of cultural remains on this landscape is continuous, and, in many cases, the application of site definition criteria did not reveal clear spatial clustering. Six sites were defined, all of which were missed during Phase I survey (Figure 7.14). During the first survey effort, one small site was discovered (LA 62901), but was not relocated during Phase II. None of the sites in this unit contain sensitive temporal information. Two had a small number of Unspecific Brown sherds, but the presence of this type only suggests a very broad, Formative period date. The remaining sites contained only nondiagnostic lithics and/or fire-cracked rock.

LA 63899 (WS 2899)

Location: UTM 384054E/3590568N (Figure 7.14)
Size: ca. 44 by 12 m; 414.7 sq m
Temporal/cultural assignment: Ceramic unknown

LA 63899 consists of a small scatter of fire-cracked rock,

Table 7.42. LA 63490 rim thickness indices

Group	Count	Mean RTI	s RTI	Min RTI	Max RTI
Plain Brownware	29	0.87	0.19	0.58	1.38
Painted Brownware	7	1.28	0.47	0.82	2.04
All Brownware	36	0.95	0.31	0.58	2.04

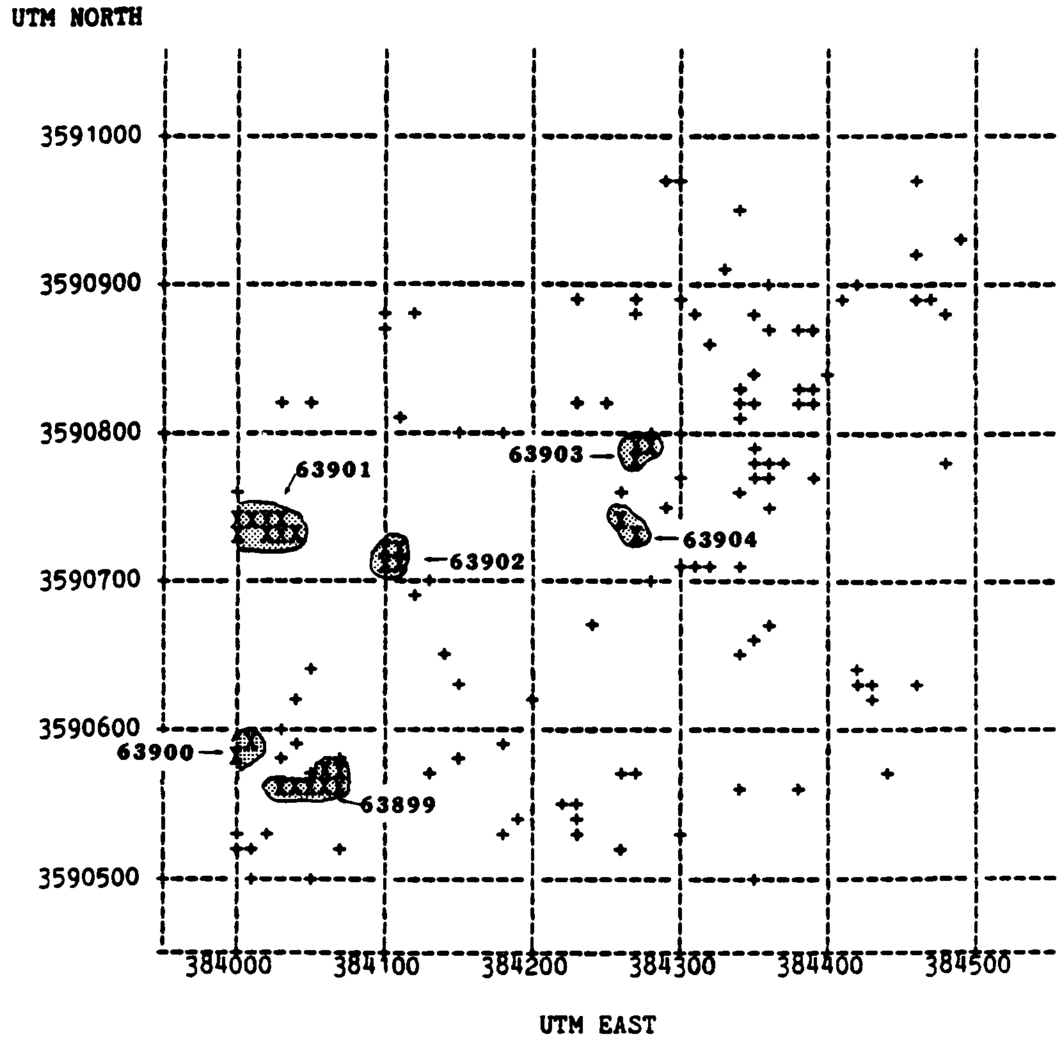


Figure 7.14. Phase II Survey Unit 5: Distribution of sites (X) and isolates (+)

lithic artifacts, and ceramics located in a large blowout. One or more disturbed hearths or roasting pits are indicated by the 96 fragments of fire-cracked rock recorded within 22 (21.22 percent) of the grids. The overall density of this debris is 0.23 fragments per sq m.

Recorded lithics—totaling 35 items—consist of 25 pieces of debitage (7 pieces of angular debris and 18 flakes), 1 basalt bidirectional core, 1 quartzite hammerstone, and 8 ground stone fragments of granite and sandstone (including fragments from a mano and a slab metate). Only five complete flakes were recorded. The majority of the debitage material is coarse-grained; 21 pieces were made of dull chert, and there was one specimen each of waxy chert, quartzite, basalt, and carbonate.

The five Unspecific Brown sherds recorded on LA 63899 suggest a Formative period occupation.

LA 63900 (WS 2900)

Location: UTM 384008E/3590590N (Figure 7.14)
Size: ca. 16 by 12 m; 150.8 sq m
Temporal/cultural assignment: Lithic unknown

LA 63900 is a small fire-cracked rock and lithic scatter exposed in a small blowout. The 18 fragments of fire-cracked rock were recorded in four grids; one of the grids contained nine pieces. The overall fire-cracked rock density for the site is 0.12 fragments per sq m. Only four pieces of lithic debitage (one piece of angular debris, two flakes, and one sharpening flake) were recorded on this site—two each of the dull and waxy chert varieties.

LA 63901 (WS 2901)

Location: UTM 384016E/3590736N (Figure 7.14)
Size: ca. 48 by 24 m; 904.8 sq m
Temporal/cultural assignment: Ceramic unknown

LA 63901 consists of a scatter of fire-cracked rock, lithics, and ceramics located in a stabilized area surrounding a low coppice dune. Thirty-three fragments of fire-cracked rock were recorded within 22 grids; maximum number of pieces per grid was four. Fire-cracked rock density for the site is low (0.04 fragments per sq m).

The lithic assemblage totals 28 items: 20 pieces of debitage (3 pieces of angular debris and 17 flakes), 1 core, 1 hammerstone, 1 retouched flake, and 5 ground stone artifacts (3 slab metate fragments and 1 from a mano). Ninety percent of the debitage is made of coarse-grained material: 17 items of dull chert, 1 of quartzite, and 2 of waxy chert. Eight flakes were complete. Platform preparation evident on these artifacts consisted of "simple" types with cortical and single facet surfaces accounting for six of the eight and collapsed platforms accounting for the other two. Eight of these flakes had no dorsal cortex, and two specimens were classified in the 11–30 percent category.

The two Unspecific Brown sherds recorded indicate a Formative period date for the site.

LA 63902 (WS 2902)
Location: UTM 384112E/3590719N (Figure 7.14)
Size: ca. 8 by 18 m; 113.1 sq m
Temporal/cultural assignment: Lithic unknown

This sparse fire-cracked rock and lithic scatter is located in a small blowout depression. The recorded assemblage consists of eight fragments of fire-cracked rock from four grids, six flakes (only one of which was complete), and four ground stone fragments (including at least two from metates). An unusually wide range of lithic materials is represented in the debitage from this site, most of which is coarse-grained. Two flakes are made of waxy chert, and there is one each of basalt, volcanic porphyry, and limestone.

LA 63903 (WS 2903)
Location: UTM 384277E/3590789N (Figure 7.14)
Size: ca. 14 by 10 m; 110 sq m
Temporal/cultural assignment: Lithic unknown

This site consists of a very small scatter of fire-cracked rock and lithic artifacts located in a stabilized area among a series of low coppice dunes. Feature observations on LA 63903 include a single charcoal stain and four fire-cracked rock concentrations. In two cases these counts may reflect the exposed remains of a hearth or roasting pit. A total of 67 fragments of fire-cracked rock were recorded in the six grids, or 21.83 percent of the site area, yielding a density figure of 0.34 fragments per sq m.

The LA 63903 lithic assemblage contains only six items: one irregular core of dull chert, five granite metate fragments, and one piece of sandstone exhibiting a ground surface that could not be classified as either a mano or a metate.

LA 63904 (WS 2904)
Location: UTM 384264E/3590738N (Figure 7.14)
Size: ca. 8 by 8 m; 50.3 sq m
Temporal/cultural assignment: Lithic unknown

LA 63904 is a very small but concentrated scatter of lithic debitage exposed in a small blowout. The site contained no fire-cracked rock or other features. A total of 23 flakes and 2 pieces of angular debris were recorded. Twenty-one of these artifacts were dull chert; waxy chert and chalcedony accounted for two items each. The assemblage includes eight complete flakes, all of which have simple platform types (seven single-facet and one cortical) and exhibit less than 10 percent dorsal cortex (seven have none). These specimens average 4.13 mm in thickness ($s = 1.36$) with a minimum of 2 mm and a maximum of 6 mm.

Sites in Survey Unit 6

Survey Unit 6 is located just above the basin floor ca. 4 km west of the foot of the Jarilla Mountains (Figure 1.3). The unit, which averages 1250 m in elevation, is located on the lowest portion of the alluvial fan and contains several small braided drainages that gradually dissipate into a series of depressions west of the survey unit. In one case, a small drainage dammed prior to the formation of White Sands Missile Range forms a small stock tank. This tank appears to have held water until quite recently as it now supports rather dense vegetation. The present ground surface appears well stabilized with wide grassy areas separating low (less than 1 m) coppice dunes held in place by stunted mesquite trees.

Intensive survey of this 500 by 500 m unit resulted in the definition of seven archeological sites within a sparse cultural landscape of isolated sherds and lithic artifacts (Figure 7.15). Some of these sites represent clear-cut clusters of cultural material, but most are less distinct and their boundaries are somewhat arbitrary. The stabilized condition of the surface may be responsible for the lack of concentrated cultural debris. This possibility is supported by the fact that virtually all of the defined sites were located in heavily eroded portions of the unit. Two of the seven sites were discovered during Phase I survey (LA 62753 and LA 62759), but one of these (LA 62759) is located on the eastern boundary of the unit and was not completely surveyed. An additional Phase I site (LA 62750) was not relocated during the intensive survey, possibly because recent deposition covered the site or because it was located on the map incorrectly. Three of the seven sites contain brownware ceramics, but no other temporally diagnostic items were recorded and efforts to extract charcoal from several deflated hearths were unsuccessful. These sites are considered ceramic unknown sites dating to the Formative period. The remaining four sites contained only nondiagnostic lithics and fire-cracked rock and are thus assigned to the lithic unknown group, which may represent a ceramic Formative period sites or Archaic sites.

LA 62753 (WS 1753)
Location: UTM 389917E/3587475N (Figures 7.15, 7.16, and 7.17)
Size: ca. 50 by 38 m; 1492.3 sq m
Temporal/cultural assignment: Ceramic unknown

LA 62753 consists of a scatter of fire-cracked rock, lithic artifacts, and ceramics. The site is exposed in two adjacent blowouts. Although a portion of this site may lie within a

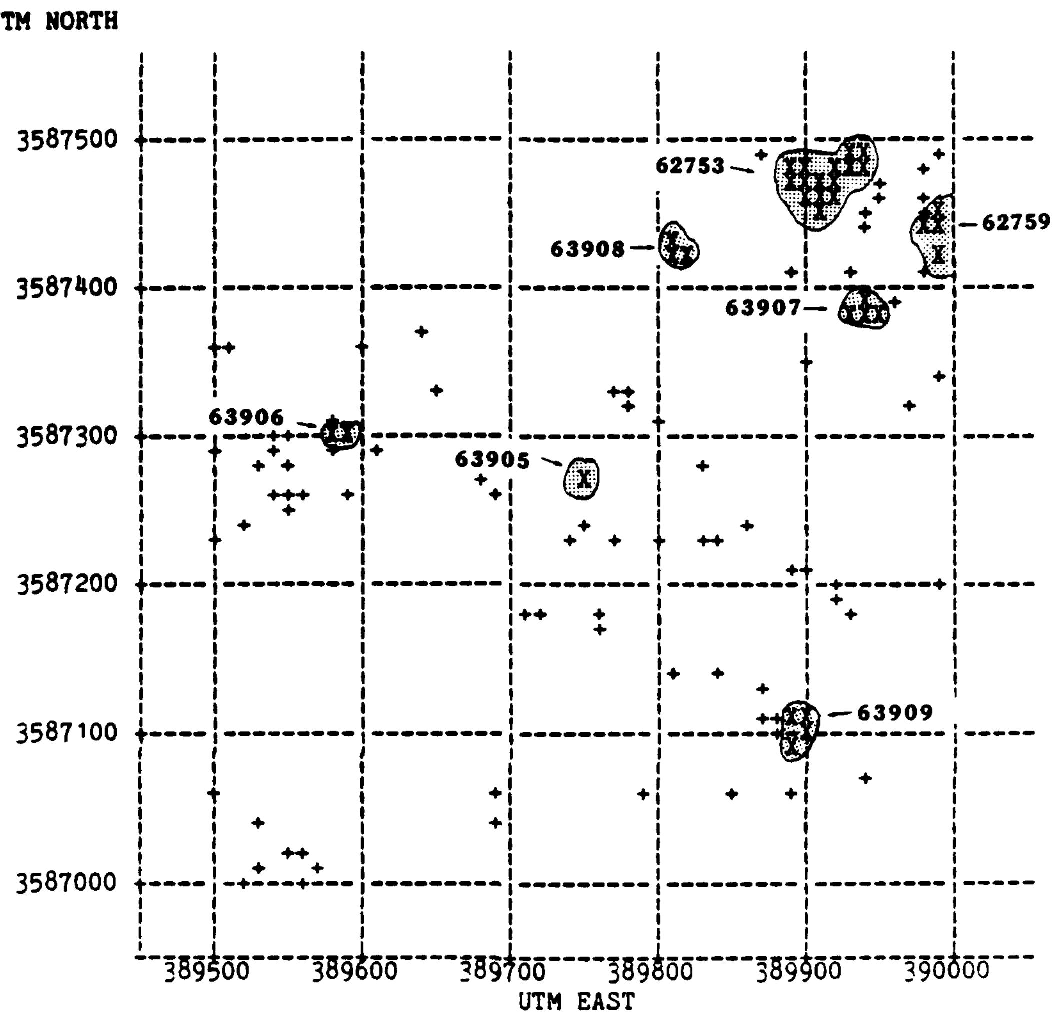


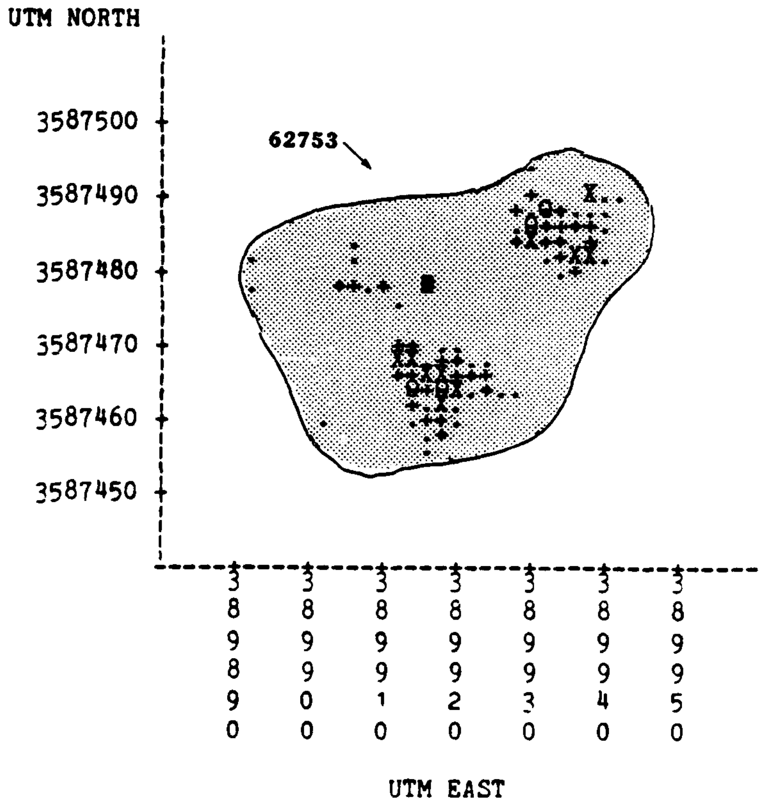
Figure 7.15. Phase II Survey Unit 6: Distribution of sites (X) and isolates (+)

narrow strip of stabilized sediments separating the two blowouts, most of the area has been completely deflated. The fully exposed remains of at least six fire-using facilities are represented by charcoal stains; unfortunately, these features did not yield enough charcoal for radiocarbon determinations. A total of 191 fragments of fire-cracked rock were recorded within 54 grids, or 14.47 percent of the total site area. The density of this material is 0.13 fragments per sq m. The maximum number of pieces per grid is 17.

Lithic artifacts recorded on LA 62753 consist of 202 pieces of debitage, 11 cores, 6 pounding tools, and 9 chipped stone tools (Table 7.44). Almost 25 percent of the debitage is angular debris, with the remaining items consisting of flakes, bifacial thinning flakes, and sharpening flakes. Raw materials present in the debitage are largely coarse-grained types; dull chert accounts for almost 70 percent of the 202 items (Table 7.45). Coarse-grained materials are present in the core assemblage in a similar proportion.

Eighty-five of the flakes are complete. Within this group more than 70 percent have single-facet or cortical platforms; only five (5.88 percent) show evidence of intentional platform preparation, such as grinding or flaking (Table 7.46). Average flake thickness for 84 of the complete flakes is 5.31 mm ($s = 4.04$), and most (69 or 81.18 percent) exhibit less than 10 percent dorsal cortex (Table 7.47). On the whole, the debitage assemblage appears to emphasize expedient, flake oriented reduction technology primarily using locally available coarse-grained materials.

Lithic tools in this assemblage include nine irregular and two unidirectional cores, six pounding implements of dull chert ($n = 4$), waxy chert ($n = 1$) and porphyry ($n = 1$), and nine chipped stone tools. The latter items consist of four pieces of retouched debitage, four unifacial tools, and one unidentified projectile point. Also, 29 ground stone fragments and 2 complete manos were recorded. The complete specimens were one-handed and had grinding surface areas



SYMBOL		TOTAL	SYMBOL		TOTAL	SYMBOL		TOTAL
......	1.000 -	4.125	XXXXXX	10.375 -	16.625	■■■■■■	22.875 -	26.000
++++++	4.125 -	10.375	000000	16.625 -	22.875			

Figure 7.16. Phase II Survey Unit 6: Total artifact density at LA 62753

of 36 sq cm and 72 sq cm. The ground stone assemblage also includes eight mano fragments and seven metate fragments—one of which is from a basin type. Twenty-seven of these tool fragments were made of sandstone; the remaining four were made of porphyry, basalt, or dull chert.

Ceramics recorded on LA 62753 consist of 28 Unspecified Brown sherds. These sherds indicate that the site dates to the Formative period.

LA 62759 (WS 1759)

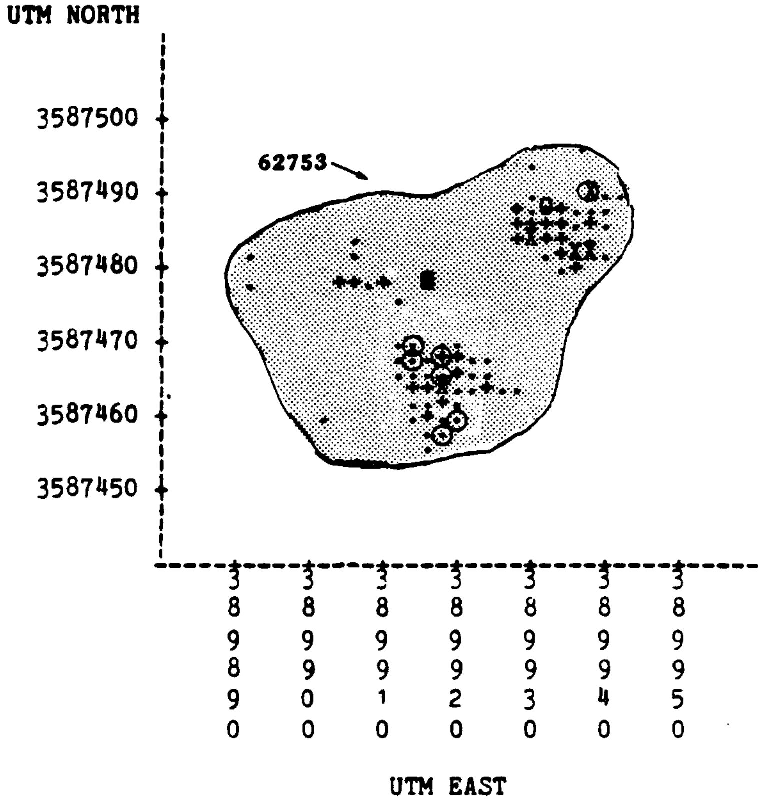
Location: UTM 389993E/3587435N (Figure 7.15)
Size: ca. 10 by 30 m; 235.6 sq m
Temporal/cultural assignment: Ceramic unknown

The portion of LA 62759 recorded during Phase II survey consists of a sparse scatter of fire-cracked rock, lithics, and ceramics located within a narrow blowout area on the windward side of a series of low coppice dunes. Approximately one-third of the site, as defined during Phase I, was documented in Phase II. The site contains 24 fragments of fire-cracked rock from 13 grids, 6 pieces of dull chert debitage, 2 irregular cores of the same material, 1 porphyry hammerstone, and 3 ground stone fragments of porphyry and sandstone (2 from metates). In addition, five sherds of Plain Other Brownware—possibly from the same vessel—were recorded on this site. The overall density of fire-cracked rock is 0.10 fragments per sq m; maximum number of pieces per grid is four.

LA 63905 (WS 2905)

Location: UTM 389751E/3587275N (Figure 7.15)
Size: ca. 2 by 2 m; 4 sq m
Temporal/cultural assignment: Lithic unknown

LA 63905 is an extremely limited scatter of lithic artifacts located in a small blowout at the foot of a low coppice dune. The entire assemblage consists of two incomplete flakes, two pieces of angular debris, and a single irregular core, all of dull chert.



SYMBOL	FCRCT	SYMBOL	FCRCT	SYMBOL	FCRCT
......	0.000 - 2.125	XXXXXX	6.375 - 10.625	■■■■■■	14.875 - 17.000
++++++	2.125 - 6.375	000000	10.625 - 14.875	O	FEATURE

Figure 7.17. Phase II Survey Unit 6: Distribution of features and fire-cracked rock (FCR) densities at LA 62753

LA 63906 (WS 2906)
Location: UTM 389590E/3587306N (Figure 7.15)
Size: ca. 4 by 4 m; 12.6 sq m
Temporal/cultural assignment: Lithic unknown

This extremely small site consists of a scatter of fire-cracked rock and lithic artifacts exposed by recent erosion between a series of low coppice dunes. The site, which covers an area of only 13 sq m, contains five fragments of fire-cracked rock from three grids, six pieces of debitage (three dull and three waxy chert), and a unidirectional or "blade" core of basalt. Two flakes of the five flakes were complete; dorsal cortex was absent from each and single-facet platforms were present.

LA 63907 (WS 2907)
Location: UTM 389944E/3587388N (Figure 7.15)
Size: ca. 12 by 16 m; 150.8 sq m
Temporal/cultural assignment: Ceramic unknown

LA 63907 is a sparse scatter of fire-cracked rock, lithics, and ceramics located in an eroded area surrounding a low coppice dune. The site contains 5 fire-cracked rock fragments in four grids, 15 pieces of debitage, 1 dull chert hammerstone, 1 unifacial tool of waxy chert, 1 piece of a basalt grinding implement, and 1 Unspecific Brown sherd. Most of the 13 pieces angular debris are dull chert (73.33 percent). The two complete flakes lacked dorsal cortex; one had a collapsed and the other a single-facet platform.

LA 63908 (WS 2908)
Location: UTM 389818E/3587428N (Figure 7.15)
Size: ca. 4 by 4 m; 12.6 sq m
Temporal/cultural assignment: Lithic unknown

LA 63908 is an extremely small scatter of lithic artifacts exposed in a blowout depression. The site contains only four pieces of dull chert debitage—three of angular debris and one flake—and six ground stone fragments, three each

Table 7.44. LA 62753 lithic artifact inventory

Lithic Type	Count	Percentage of Total	Percentage of Type
Debitage			
Angular Debris	50	19.23	24.75
Flake	128	49.23	63.37
Biface Flake	11	4.23	5.45
Sharpen Flake	13	5.00	6.44
Subtotal	202	77.69	100.01
Cores			
Irregular Core	9	3.46	81.82
"Blade" Core	2	0.77	18.18
Subtotal	11	4.23	100.00
Pounding Tools			
Hammer	6	2.31	100.00
Chipped Stone Tools			
Retouched Angular Debris	3	1.15	33.33
Retouched Flake	1	0.38	11.11
Projectile Point	1	0.38	11.11
Uniface	4	1.54	44.44
Subtotal	9	3.45	99.99
Grinding Tools			
Unknown Ground Stone	14	5.38	45.16
Unknown Mano	8	3.08	25.81
One-hand Mano	2	0.77	6.45
Unknown Metate	6	2.31	19.35
Basin Metate	1	0.38	3.23
Subtotal	31	11.92	100.00
Total	259	99.60	

Table 7.45. LA 62753 lithic material summary

Material Type	Count	Percentage of Total	Percentage of Type
Debitage			
Waxy Chert	37	14.23	18.32
Dull Chert	140	53.85	69.31
Quartzite	2	0.77	0.99
Basalt	2	0.77	0.99
Rhyolite	9	3.46	4.46
Sandstone	1	0.38	0.50
Granite	3	1.15	1.49
Carbonates	8	3.08	3.96
Other Misc			
Subtotal	202	77.69	100.02
Cores			
Waxy Chert	3	1.15	27.27
Dull Chert	7	2.69	63.64
Basalt	1	0.38	9.09
Subtotal	11	4.22	100.00
Total	2132	81.91	

Table 7.46. LA 62753 complete flake platforms

Platform	Count	Percent
Collapsed	14	16.47
Cortical	32	37.65
Single Facet	28	32.94
Multi Facet	62	7.06
Prepared	5	5.08
Total	85	100.00

of sandstone and volcanic porphyry. Four of the ground stone fragments are from metates.

LA 63909 (WS 2909)

Location: UTM 389902E/3587108N (Figure 7.15)
Size: ca. 10 by 20 m; 157.1 sq m
Temporal/cultural assignment: Lithic unknown

This site is a limited fire-cracked rock and lithic scatter located in an eroded exposure east of a large coppice dune. The site contains four fragments of fire-cracked rock from four different grids, seven pieces of debitage (three flakes and two biface flakes), one unidirectional core of dull chert, and two sandstone ground stone fragments. Four of the seven pieces of debitage are made of dull chert.

Table 7.47. Amount of dorsal cortex on complete flakes from LA 62753

Cortex	Count	Percent
None	61	71.76
1–10 Percent	9	10.59
11–30 Percent	6	7.06
31–80 Percent	6	7.06
81–100 Percent	3	3.53
Total	85	100.00

Chapter 8

PHASE II ANALYSIS RESULTS

Timothy J. Seaman

Before presenting the results of Phase II analyses, qualification should be made regarding the comparability of the analytical units used here to those defined elsewhere. As previously discussed in Chapters 2 and 7, the criterion used to define Phase II site boundaries was quantitative in nature and was applied after the completion of the survey. Site definition was performed in as objective and consistent a fashion as possible and used an arbitrary minimum threshold of artifact density to separate site areas (and assemblages) from nonsite areas (and isolated artifacts). Owing to this situation and the very high intensity of the Phase II survey effort, the resulting sites should not be seen as directly comparable, in terms of either site size or assemblage composition, to sites defined by previous investigations in the Tularosa Basin and Hueco Bolson.

Preformative Period Sites: Identification and Chronology

Seven sites documented during Phase II date to the Paleoindian or Archaic periods. The single Paleoindian site (LA 63880), described in Chapter 17, was initially identified during Phase I and tentatively dated on the basis of diagnostic tool types. This site is not considered here because none of the other collected data are comparable. The remaining six sites are Archaic. One (LA 62896) has been dated to the Middle to Late Archaic and another (LA 63890) to the Late Archaic on the basis of diagnostic projectile points. LA 62126, a multicomponent site with a radiocarbon date and a diagnostic projectile point dating to the Late Archaic period, also contained a later radiocarbon date and a small number of ceramics, which suggests use during the Early Mesilla phase. Another radiocarbon date from this site also suggests use during the Doña Ana phase. Three other very small lithic sites in Survey Unit 1 (LA 63883, LA 63884, and LA 63886) yielded radiocarbon dates in the Late Archaic period, but contained no diagnostic artifacts. Finally, 21 small lithic sites with unknown cultural/temporal affiliations were recorded, some or all of which may date to Preformative times.

With the exception of LA 62126, all Archaic sites are located in Survey Units 1 and 2 well out into the basin floor. LA 62126 is located on the alluvial fan in Unit 3. Although it is possible that additional Archaic period sites are located in these survey units, they are either well-buried or their identities are masked by later, ceramic period occupations. Buried remains are almost a certainty given the active depositional environment of the fan. With the very intensive Formative period occupation of large portions of the Jarilla alluvial fans, it is clear how difficult it would be to isolate earlier Archaic sites on the basis of survey data. Also of relevance is the fact that all of the large, ceramic sites on the fans investigated during Phase II contained projectile point types dating to the Archaic period with the early, middle, and late divisions represented. Without intensive excavations of these and other similar sites, it is impossible to discern whether the occurrence of these points is due to recycling or scavenging or to the presence of hidden Preformative assemblages at these locations.

Two major problems have thwarted the identification and accurate temporal placement of Preformative remains: one concerns methodology and the other is conceptual in nature. Methodological problems include difficulties in assigning precise temporal periods to the remains and in distinguishing these remains from aceramic Formative period sites. Archaic sites are most commonly identified during survey by the presence of allegedly diagnostic projectile point types. In the Tularosa Basin, however, little confidence should be placed in the use of extant typologies from Trans-Pecos Texas (Suhm and Jelks 1962), Oshara Tradition types from northern New Mexico (Irwin-Williams 1973, 1979; Irwin-Williams and Tompkins 1968), or Cochise materials from areas to the west (Beckett 1973, 1980; Dick 1965; Sayles and Antevs 1941). As is pointed out in Chapter 15, reliable local typologies need to be developed before sites can be dated with confidence to any subdivision of the Archaic period on the basis of projectile points.

For small sites lacking projectile points—and these are in the majority—temporal placement is even more elusive. A number of other criteria based on differences in lithic technology have been offered as being possibly diagnostic of Archaic period sites, but these are perhaps premature. For instance, it has been suggested that broad lithic material diversity and an emphasis on high-quality materials are characteristic of Archaic assemblages and may be useful in distinguishing between Archaic and post-Archaic remains (Carmichael 1983; Kerley and Hogan 1983; Whalen 1977). The variability in lithic reduction strategies—and especially, an emphasis on biface manufacture—among "lithic unknown" assemblages has also been suggested as a useful diagnostic of Archaic assemblages (Chapman 1977; Kerley and Hogan 1983; Laumbach 1980; Schutt 1983; Vierra 1985). Both of these approaches are based upon demonstrated patterning of considerable strength in known Archaic assemblages and seem reliable.

There are several problems with these technological "signature" approaches to chronology. Lithic material diver-

sity in a given assemblage may be conditioned not only by mobility (as is commonly assumed for Archaic period adaptations), but also by local availability of raw materials, task-specific requirements, complex or long site-use histories (i.e., multiple occupation or reoccupation), and other strictly situational factors (Binford 1977, 1979, 1982). Similarly, one can easily envision situations in which Archaic groups might reduce lithic materials for purposes other than the manufacture of bifacial blanks and tools, or how a seemingly "Archaic" assemblage might be created by later adaptations. Reuse of Archaic sites by post-Archaic populations for lithic provisioning may also confuse attempts at chronological placement on the basis of reduction measures (Vierra 1985:138–163).

Variability evident in the Phase II sites appears to support generally expected technological "signatures." Archaic assemblages appear to have a considerably higher proportion of fine-grained lithic material types than later ones. Figure 8.1 shows a continuous increase in the proportion of coarse-grained materials (and a concomitant decrease in fine-grained types) from the Middle to Late Archaic to the Doña Ana phase.

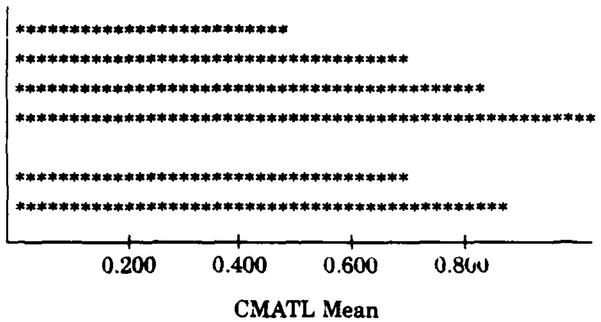
Archaic assemblages also exhibit the expected emphasis on later reduction stages and more refined techniques associated with biface manufacture and maintenance. Figures 8.2 and 8.3 illustrate the very low mean flake thickness and the high proportion of prepared platforms in the Phase II Archaic assemblages relative to data from later periods.

Further support for this expectation may be seen in the high proportion of bifacial thinning and resharpening flakes in Archaic assemblages (Figure 8.4). An extremely high debitage-to-core ratio for Archaic assemblages is also indicative of more advanced or refined reduction activities (Figure 8.5).

It should also be noted that the general trends in lithic technology measures from the Archaic to the Formative period are—with one exception (debitage-to-core ratios)—mirrored in differences between lithic unknown and ce-

Figure 8.1. Proportion of coarse-grained material in debitage from Ph II sites

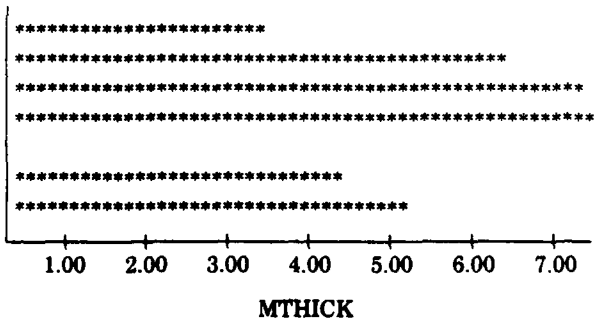
Bar Chart of Means



Phase	No. of Sites	CMATL Mean
Mid-Late Archaic	2	0.476
Late Arch-E Mes/DA	1	0.677
L Mesilla	3	0.767
Doña Ana	1	0.930
Lithic Unknown	9	0.672
Ceramic Unknown	4	0.879

Figure 8.2. Mean flake thickness (mm) in Phase II site assemblages

Bar Chart of Means



Phase	No. of Sites	MTHICK
Mid-Late Archaic	2	3.31
Late Arch-E Mes/DA	1	6.34
L Mesilla	3	7.16
Doña Ana	1	7.56
Lithic Unknown	9	4.48
Ceramic Unknown	4	5.13

Figure 8.3. Proportion of complete flakes with prepared platforms in Phase II site assemblages

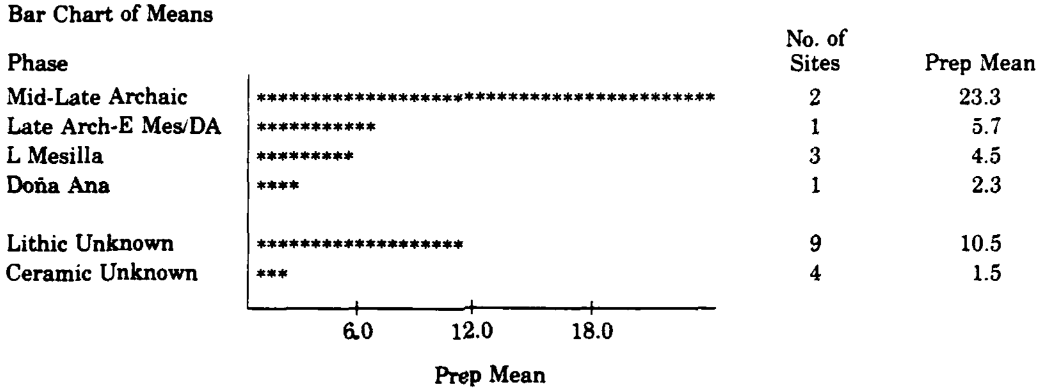


Figure 8.4. Proportion of bifacial thinning and resharpening flakes in Phase II site assemblages

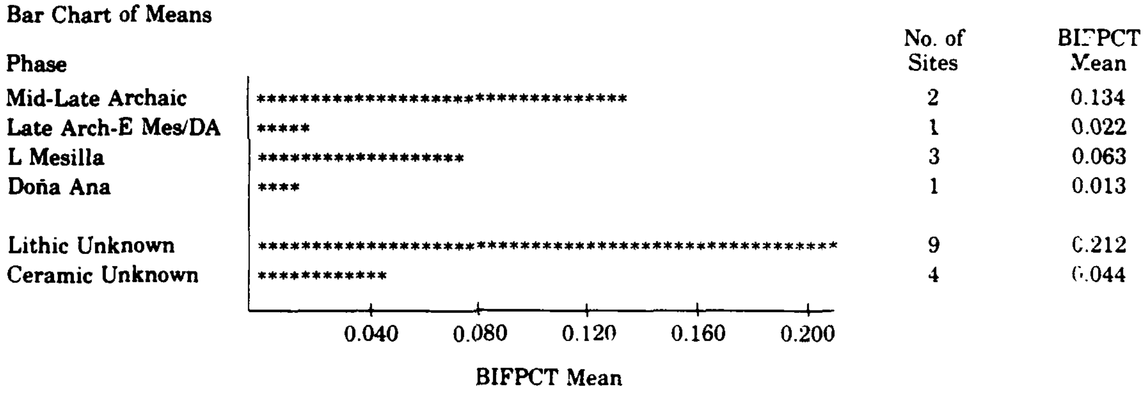
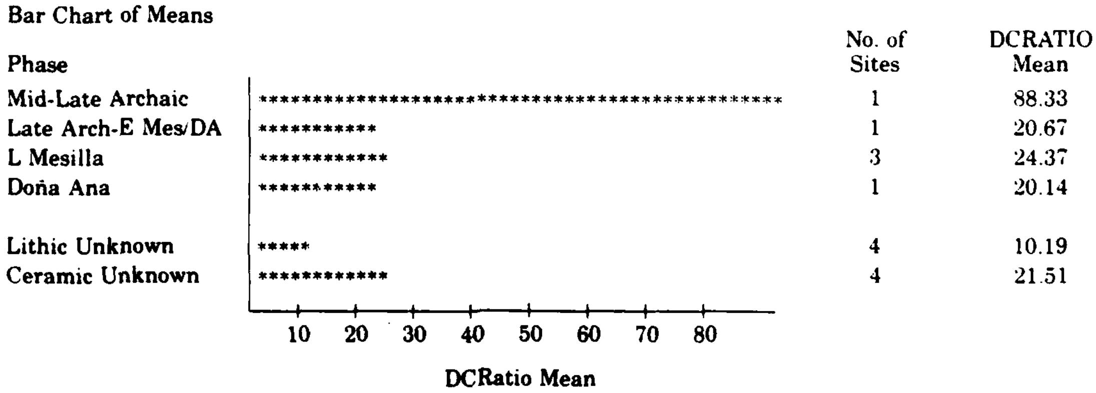


Figure 8.5. Debitage-to-core ratios at Phase II sites

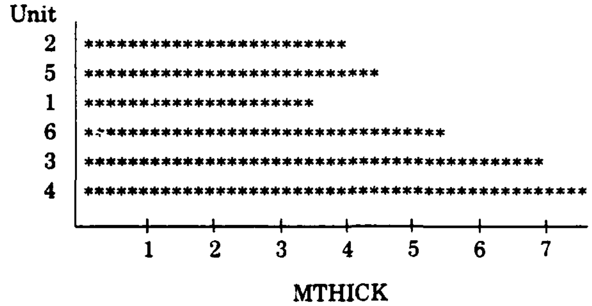


ramic unknown sites. Although the lithic unknown site grouping is likely to include aceramic Formative period sites as well as preceramic sites, this pattern suggests that in terms of lithic technology the lithic unknown sites are more similar to Archaic patterns than to Formative assemblages.

It is likely that many of these technological measures are correlated with the distribution of raw materials in the basin as well as being a direct result of adaptational differences between Archaic and Formative systems (O'Laughlin 1977b). That is, the almost total absence of raw material sources in the central basin may condition how raw materials are utilized, regardless of the "modal" tendencies in the technique of lithic reduction of various cultural/temporal affiliations. It is expected that as raw materials are transported farther from their source there should be a concomitant increase in emphasis on later stages of reduction due to increasing replacement costs (Hard 1983a; Mauldin 1984). A decrease in degree of expedient flake-oriented reduction evidenced in assemblages is also expected with increasing distance from raw material sources.

Although it is difficult to control for variability introduced by proportional differences in Preformative versus Formative settlement intensity among the Phase II survey units (e.g., there are more Formative and fewer Archaic remains in units near the Jarillas, and vice versa), the above expectation is reflected in the Phase II data. Pronounced differences in the way dull chert is utilized can be seen as one moves from the basin floor closer toward its source in the Jarilla Mountains and alluvial fans. When all site assemblages (complete dull chert flakes only) are collapsed by survey unit and the units are arranged according to their decreasing relative distance from the Jarillas, pronounced trends in measures of reduction stage can be seen. Figures 8.6–8.8 illustrate an increase in mean flake thickness, a decrease in the proportion of prepared platforms, and although less pronounced, a decrease in the proportion of flakes with less than 10 percent dorsal cortex among assemblages in successively closer proximity to the sources of raw material. Figure 8.9 shows that much higher debitage-to-core ratios occur in survey units in the basin floor than in survey units closer to the sources.

Figure 8.6. Mean flake thickness for dull chert complete flakes from Phase II sites



Note: Units ordered by decreasing distance from the Jarilla Mountains.

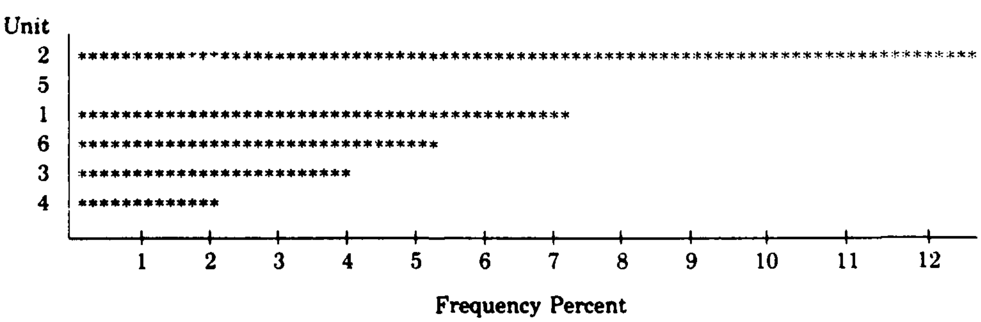
Taken together, these trends reflect the expected increase in later-stage reduction activities with increasing distance from raw material sou ce locations, and more expedient reduction trajectories at or near source locations.

It is worth noting that the relative distances being considered here are not particularly large and may well be within a single day's foraging distance for hunter-gatherer groups. The maximum distance from presumed lithic sources in the Jarilla Mountains to the project area (ca. 10 km or 6.2 mi) is almost entirely within Binford's (1980) suggested 6 mi daily foraging radius around a residential base.

Formative Period Sites: Identification and Chronology

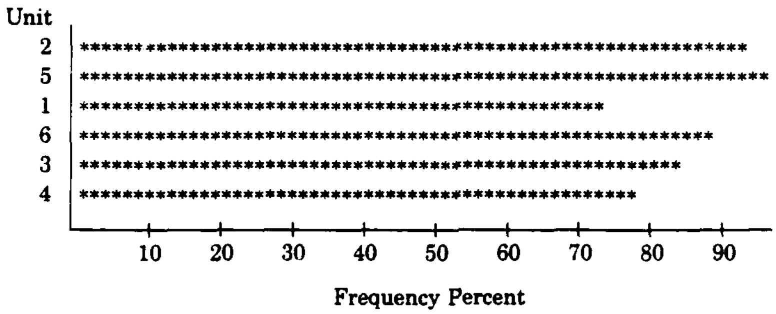
Twelve recorded sites date to the Formative period on the basis of ceramic evidence and, in two cases, on the basis of radiocarbon determinations. As noted above, LA 62126 is a multicomponent site with dates suggesting use during the Late Archaic and Early Mesilla phases. A very late radiocarbon date for this site (AD 1180) indicates occupa-

Figure 8.7. Percent of prepared platforms in dull chert complete flakes from Phase II sites



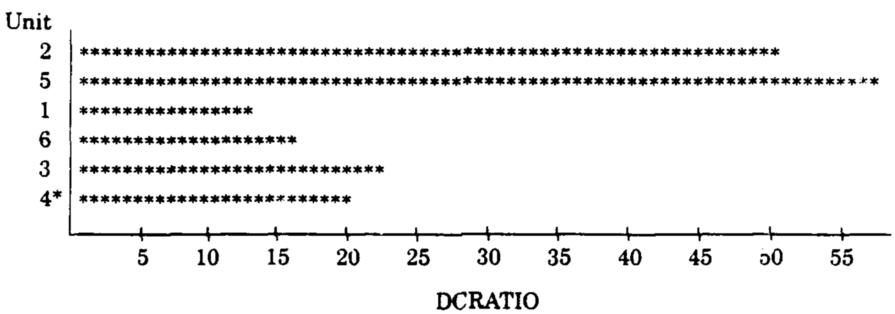
Note: Units ordered by decreasing distance from the Jarilla Mountains.

Figure 8.8. Percent of dull chert complete flakes from Phase II sites with <10 percent dorsal cortex



Note: Units ordered by decreasing distance from the Jarilla Mountains.

Figure 8.9. Debitage-to-core ratios for dull chert artifacts from Phase II sites



Note: Units ordered by decreasing distance from the Jarilla Mountains.
UNIT #4 WAS LOCATED ENTIRELY WITHIN LA 62490.

tion during the Doña Ana phase as well, but the very small number of sherds found on this site (9 Unspecified Brown sherds) may reflect greater use during the earlier Preformative periods. The other site yielding radiocarbon dates (LA 62125) also appears to be multicomponent; dates of AD 150, 700, and 1090 indicate possibly continuous use throughout the 1100-year long Mesilla phase.

The remaining Formative period sites were dated on the basis of ceramic assemblage content. In the case of LA 62124, the admixture of Mogollon Red-on-brown and unspecific Mimbres Whitewares with El Paso Brownwares suggests a date of ca. AD 700 to 1100. Rim thickness index statistics for the El Paso Brown rims (mean RSI = 0.83: $s = 0.10$; $n = 22$) are also consistent with other assemblages from this 400–year period (see Chapter 13). LA 63892 was dated to the Mesilla phase because a single unspecific Mimbres Black-on-white sherd was found along with a large number of Unspecific Brown sherds. The rest of the Formative period sites contained only Unspecific Brown sherds and must be considered as ceramic unknown sites for analytical purposes.

The most recent site investigated during the Phase II survey is LA 63490. At first inspection, the ceramics from this site appear to be a classic Doña Ana assemblage with Mimbres Whitewares in association with Chupadero Black-on-white and both plain and painted El Paso Brownware types. Rim thickness statistics for El Paso Bi/Polychrome sherds (mean = 1.28; $s = 0.47$; $n = 7$) are also consistent with Carmichael's (1983:83) figures for the Doña Ana phase, but the presence of early variants of Mimbres Black-on-white (Styles I and II) suggests an earlier and perhaps multicomponent temporal assignment. An inspection of El Paso Brown rim thickness statistics also suggests an earlier Late Mesilla date; when RSI means for El Paso Brown rims from LA 62124 and 62125 are compared with those from LA 63490, there are no statistically significant differences at the 0.05 confidence level (Table 8.1).

If the chronological placement of LA 62124 and LA 62125 in the Mesilla phase is correct, then the RSI differences in El Paso Brown rim thickness between these sites and LA 63490 are smaller than expected. Variability within the LA 62125 and LA 63490 El Paso Brown samples is quite high, as evidenced by the coefficients of variability (CV), and an almost complete overlap exists within 95 percent confidence intervals for the three samples (Table 8.2). This overlap in variability makes it difficult to identify temporal differences among these three sites. Al-

Table 8.1. Comparison of LA 62124, LA 62125, and LA 63490 Rim Sherd Index statistics (jars only)

Site	Ceramic Type	N	Mean RSI	s
62124	El Paso Brown	19	0.83	0.10
62125	El Paso Brown	49	0.86	0.18
63490	El Paso Brown	29	0.87	0.19
63490	El Paso Bi/Polychrome	7	1.28	0.47
63490	All Brownware	36	0.95	0.31

t-test Comparison						
Sample 1	Sample 2	Ceramic Type	Difference in Mean RSI	| *t* |*	*df*	Significant**
62124	62125	El Paso Brown	0.03	0.855 –	60	No
62124	63490	El Paso Brown	0.04	0.826 =	46	No
62125	63490	El Paso Brown	0.01	0.229 =	76	No
62124	63490	All Brownware	0.12	2.089 –	48	Yes
62125	63490	All Brownware	0.08	1.539 –	53	Yes

*– variances assumed unequal; = variances assumed equal
**one-tailed test; 0.05 confidence level

Table 8.2. El Paso Brown Rim Sherd Index statistics

Site	95 Percent Confidence Interval	CV
LA 62124	< – – – * – – – >	0.12
LA 62125	< – – – – * – – – – >	0.21
LA 63490	< – – – – – * – – – – – >	0.22

0.70 0.80 0.90 1.00

Mean Rim Sherd Index

though the use of rims to date assemblages appears in Lehmer's (1948) initial description of the Jornada Mogollon, the technique as applied here is still in its infancy. The minimal differences between site RSI means and the high variability within the LA 62125 and LA 63490 assemblages may be due to any number of factors concerned with length of occupation and/or site function, as reflected in vessel form variability (e.g., assemblages with high proportions of jar forms, which tend to have more direct rim forms, will exhibit high RSI values) and the range of ceramic types present (e.g., the presence of decorated El Paso Brownwares and tradewares on LA 63490).

It is thus possible that the sample of the LA 63490 assemblage results from long-term, continuous residential occupation or reoccupation during the Mesilla and Doña Ana or early El Paso phases. In other words, the co-occurrence of Mimbres and painted El Paso Brownwares in this assemblage—one of the basic criteria for identification of Transitional Pueblo sites—may be due to a mixing of temporally and perhaps spatially discrete occupations in or near the 100 by 100 m surveyed area. Another ceramic criterion used in defining Doña Ana phase assemblages is the co-occurrence of El Paso Brown with thickened rims and El Paso Polychrome with direct rims (Carmichael 1983:69–74). Rim thickness statistics from the El Paso Brownware rims from LA 63490 do not conform to this pattern, but suggest that a mixed assemblage is possible. As outlined in Table 8.1, El Paso Brown rims are slightly pinched (RSI = 0.87) rather than thickened, and the El Paso Polychrome rims are thickened (RSI = 1.28), a situation that almost always correlates with everted rather than direct rim forms (see Chapter 13).

The validity of current conventions for defining Doña Ana phase remains solely on the basis of ceramic assemblage characteristics can be questioned given these observations. The constellation of ceramic types diagnostic of this phase has been shown by Carmichael (1983:68–76, 1985:45–53) to exist in contexts that seem to be the result of single occupations (i.e., "mound" middens), but little effort has been made toward systematically evaluating the length of time involved in the formation of these features and the possibility of multicomponency as a contributing factor.

Because of these uncertainties several researchers in the Tularosa Basin have abandoned the use of this poorly defined phase and have set cutoff dates in the range of AD 1100–1200 for separating the Late Mesilla and El Paso phases (Anyon 1985; Eck 1979; Whalen 1981a).

The abandonment of attempts to document the Doña Ana phase is unfortunate, for the period of transition between what are recognized as the Late Mesilla and El Paso phases—the Pithouse-to-Pueblo transition in Whalen's (1981a) terms—is crucial to our understanding of major widespread adaptational changes in the Jornada region. If demonstrable, the analytical utility of an unambiguously recognized period of transition cannot be questioned. A general abandonment of the Doña Ana or Transitional Pueblo phase by Jornada scholars simply because of current ambiguities in recognition would indeed be counterproductive. Clearly, research aimed at resolving the existing recognition problems is necessary, but what directions can and should such efforts take?

Continued research concerned with increasing the precision with which ceramic types can be used to infer dates of occupation is one productive direction. Because of the chronological importance placed on such key ceramic types as Mimbres Black-on-white, El Paso Bichrome/Polychrome, and the various El Paso Brownware types, it is imperative that their respective dates of manufacture be confirmed. In the case of Mimbres wares, it is also crucial to determine whether locally manufactured variants of this type in the Tularosa Valley and Hueco Bolson do in fact postdate production of this ware in the Mimbres Valley, as Carmichael (1983:68) has suggested. This area of research is considered further in Chapter 14.

Current assumptions regarding periods of production and type replacement sequences within the local El Paso Brownware types are in need of evaluation. Commonly used beginning dates for El Paso Bichrome and Polychrome are in need of refinement—especially in the case of El Paso Bichrome, as it is seen by many as developmentally intermediate between El Paso Brown and El Paso Polychrome. Although El Paso Brown may have persisted throughout most of the 1400-year Formative period, its utility in chronological studies is potentially greater than that of its painted counterparts for identifying Transitional Pueblo assemblages. The further development of rim dating techniques using El Paso Brown is considered crucial, as this type can be seen as a common denominator in most late Formative ceramic assemblages. As shown in Chapter 13, although temporally sensitive patterns in El Paso Brown rim forms have been well documented, the effects of variability in vessel form, site function, and other factors have yet to be adequately considered.

Ultimately, excavation data providing chronometrically dated assemblages are essential to all of these lines of research. No chronologically sound corpus of data is currently available for addressing the Doña Ana—or any other—problem. Although some advances can be made using data generated by archeological survey alone, as has been demonstrated here, the importance of tethering assemblages to chronometric dates remains paramount if these problems are to be resolved through conventional analytical approaches.

Residential Mobility in the Late Mesilla Phase

Data collected during the Border Star 85 Phase II survey are considered here in light of certain components of Hard's (1983a) model of adaptation for the Late Mesilla phase (AD 750–1000) in the greater Tularosa Basin and Hueco Bolson. The components of the model considered here are those concerning the nature of mobility strategies of Late Mesilla phase groups. As outlined previously in Chapter 2, the objective of this section is not to evaluate rigorously the validity of this model or even limited portions of it. The data collected during Phase II survey are most certainly inadequate for this. Rather, this discussion represents a "preliminary attempt to recognize some theoretically expectable, but as yet undocumented, components of archeological variability thought to exist in the Jornada Mogollon region" (U.S. Army Corps of Engineers 1984:c-13).

The Model

The model provides a set of expectations concerning seasonal variability in subsistence and land use strategies. In its simplest form, the model suggests that

> groups during the Late Mesilla Phase would subsist on some cultigens and substantial amounts of wild plant and animal products. The location of the base camps and the type of mobility strategy used would be in response to the congruence or lack of congruence of plant products, animals, fuel, and water (Hard 1983a:16).

The region is divided into four broadly defined environmental zones: Mountain (i.e., the Sacramento and Organ/Franklin chains), Mountain Periphery (i.e., the alluvial fans below the two mountain chains), Central Basin (i.e., the Tularosa Basin and Hueco Bolson floor), and Riverine (i.e., the Rio Grande Valley). In terms of this stratification, the Border Star 85 project area lies entirely within the the Central Basin zone. On a local rather than regional level, the classification is not as simple because the project area contains an anomalous topographic feature—the Jarilla Mountains—and therefore exhibits some characteristics of the Mountain Periphery zone that are crucial in discussions of human adaptations. The Jarilla Mountains create runoff situations that figure prominently in Hard's model as conditioners of seasonal mobility patterns and as a focus of agricultural activities within the region.

The Jarillas and their alluvial fans lack certain important features of the regionally defined Mountain Periphery zones, however. As described in Chapter 3, the area drained by the Jarillas and their orographic effects on precipitation patterns is expected to be minimal compared to similar situations at the edges of the basin. Thus, significantly less water is available for agricultural or domestic use than in the true Mountain Periphery zones. Although small seeps or springs exist in some areas of the Jarillas, it is reasonable to assume that such sources of water were never plentiful, and it is likely that playas fed by seasonal runoff held significantly less water for less time than did those below the Organ or Franklin mountains, such as Old Coe Lake. Another important difference between the basin margins and the project area is that the Jarillas are quite isolated and do not afford easy access to resources at higher elevations. Modern vegetation in the Jarillas is probably

an artifact of intensive mining and ranching activities in the early 1900s and does not reflect prehistoric patterns. It is doubtful, however, that the project area ever contained a diversity of biotic resources comparable to that found in areas at similar elevations in the Sacramento or Organ/Franklin mountain chains.

Late Mesilla adaptations are modeled in terms of four seasons defined on the basis of annual climatic variation. Summer is defined by the occurrence of precipitation from moist Gulf of Mexico air masses between July and mid-October. Fall extends to mid-November and represents the period between the abatement of summer rains and the first frost. The period from mid-November until mid-March is classified as the winter frost season, and spring covers the period between the last frost and the start of the summer rainfall (mid-March to June).

Components of Hard's model of Late Mesilla adaptations concerned with seasonally distinct patterns of residential mobility are relevant to the Border Star 85 project area mainly during the spring and summer seasons. It is suggested that spring residential bases would be located in Mountain Periphery or Riverine zones and would be a continuation of the largely sedentary winter settlement pattern. (The latter zone refers to the Rio Grande Valley and thus is of little immediate concern here.) In the Mountain Periphery zone mobility is expected to be variable, involving components of both collector (i.e., moving resources to people) and forager (i.e., moving people to resources) strategies (Binford 1980). Springtime mobility is expected to be conditioned mainly by spatial/temporal congruence of water sources in the form of springs, by locally available plant and animal resources (especially leaf succulents, such as agave and yucca, and rabbits), and by the status of winter stores. Specific residential locations and site contents within this zone should reflect attempts to maximize access to all three of these resources through mobility. An increase in residential moves and a decrease in logistical mobility is expected as winter stores are depleted. Similarly, the "tethering" effect of local water sources would diminish as water became more widely available with the advent of summer rains. This zone is also thought to have been utilized in the late spring for planting agricultural fields prior to the arrival of summer precipitation and runoff from higher elevations. Late summer or early fall occupation of the alluvial fans for harvesting and processing agricultural produce is also expected.

It seems unlikely that the Jarilla Mountains were the focus of all of these activities. First, the Jarillas are far from areas suggested by the model as crucial for winter base camps. Most important of these winter locations are mountain environs where large game and fuel are abundant. The availability of both of these resources is limited by the minimal area of the Jarillas, and the fuel wood and large game that do occur would be easily depleted. As noted previously, water is rare in comparison with its occurrence in the foothills at the basin margins, and this factor would severely limit winter and spring habitation of any magnitude. There is little evidence that leaf succulents, such as agave, were present in large quantities in the Jarillas, and at present there appears to be little archeological evidence—in the form of burned rock mounds or ring middens—reflecting intensive exploitation. More likely candidates for loci of these expected early spring activities may be found below the Sacramentos: specifically, at such sites as the Fairchild site (Anyon 1985:137–139), where intensive succulent processing as well as domestic activity is evident. In summary, spring habitation (as described by Hard) within the project area would be not be impossible, but the use of this area during the spring cannot be expected to mirror closely the predicted patterns in "true" Mountain Periphery zones at the basin margins, and a certain amount of translation is necessary. We will return to this line of reasoning below.

The model predicts that summer is the period of greatest activity in the basin floor zone.

> The summer is the period of greatest congruence of resources. Water, food, and fuel would be available around playas in the basin, along the playas at the base of the mountain[s] and along the Rio Grande. Wild seeds would be gathered for immediate consumption, as well as storage. The warm weather would require only small cooking fires so fuel requirements would be low. Rabbits would be at their peak population. Deer would probably not be hunted due to their scattered distribution (Hard 1983a:12).

In addition, the planting and limited maintenance of agricultural fields located on alluvial fans at the edges of the basin is predicted as an important early summer activity. It is suggested that the level of agricultural activity would be low, however, and that the fields might be completely or partially abandoned in favor of foraging pursuits in the central basin in a fashion similar to ethnographically known patterns for the Western Apaches (Buskirk 1949; Goodwin 1935, 1942) and for Lower Colorado River groups (Castetter and Bell 1951; Gifford 1933).

During this season, residential sites within the basin are expected to be situated in places where water, wild seed crops, and rabbits are available. Because water sources in the basin floor are limited to playas, while plants and small game are, for the most part, ubiquitous, a foraging pattern of mobility is predicted in which water is the key locational factor. The frequency of residential moves and duration of occupation at any given base camp would be a function of depletion of any one of these critical resource types within a daily foraging radius of that site (Binford 1980). This expected pattern is quite similar to those reported ethnographically for the ¡Kung (Yellen 1977), where residential base camps were often "tethered" to water holes for extended periods and served as centralized loci for daily foraging activities.

Implications for Border Star 85 Survey Results

As stated previously, some translation of the regional model must be made to adjust for environmental variability on a local level. In this case, the local level is defined by the areal extent of the project area and by the unique environmental situation created by the Jarilla Mountains.

In terms of adaptational expectations, one might expect some kind of hybrid strategy incorporating components of both spring and summer patterns of land use and subsistence. The location of agricultural fields on the alluvival fans along the base of the Jarillas adds an additional factor

to mobility decisions—and one that is quite different from the availability of water, fuel, and wild food sources. The principal difference is that there is no immediate return from agricultural activities in terms of subsistence during a significant portion of the crop maturation cycles. Foraging in the basin floor would still be necessary to provide food, so during the spring and early summer one of two basic mobility options would have to be taken in order to solve this lack of congruence:

1) opt to invest minimal effort in planting and early maintenance of agricultural fields and continue to move people to resources in the basin floor (the forager option), or
2) opt to substitute logistically organized (i.e., task-specific) mobility for the reduced number of residential moves required owing to investment in agricultural activities (the collector option).

It should be added here that the forager option alluded to above is probably representative of adaptational patterns that have considerable time depth within the Formative period, extending to Early Mesilla and perhaps even Late Archaic times. In contrast, the collector option would be a step in the direction of increased sedentism and dependence on agriculture—a course that was increasingly taken by Jornada Mogollon groups during the succeeding Doña Ana and El Paso phases.

When the isolation of the Jarilla Mountains and the probability that they were unsuitable for winter habitation are considered, it seems most likely that the project area would be exploited during the Late Mesilla phase as part of the proposed summer foraging pattern. That is, agricultural activities would be embedded in the basic summer foraging pattern of moving people to resources with a high number of relatively short duration, residential moves among playa water sources in the basin.

At this point, a series of predictions could be made on the basis of the model concerning what archeological sites should look like in the portions of the Border Star 85 project area surveyed during Phase II. Hard does present a series of expectations regarding variability in Late Mesilla architecture, ceramic, lithic, and ground stone assemblages (Hard 1983a:18–26). These predictions could then be compared with the Phase II site data and discussed in terms of how well the data fit these expectations. Comparisons of this sort are complicated, however, by factors that render them meaningless or, at best, ambiguous.

First, the required level of temporal control implied in Hard's model is simply not attainable in the Phase II sample. As documented in the site descriptions (Chapter 7), single component sites that can be confidently attributed to the Late Mesilla or to any other specific phase are quite rare. Those sites that conform to currently accepted dating criteria for this phase (i.e., mainly ceramic evidence) are quite extensive and are known on the basis of radiocarbon dates to be the result of long-term reoccupation extending at least to the Early Mesilla phase. For this reason a broader temporal perspective must be taken, and it must be assumed that the basic attributes of Hard's predicted summer pattern have considerably more time depth than he originally intended.

The second and probably most crucial factor is that Hard's model is essentially static. It does not consider what the cumulative archeological results of the operation of this system might be, nor does it specify factors that might cause it to change through time. The model provides only a series of behavioral expectations for an idealized adaptational system on a regional scale. It provides few, if any, empirical expectations that take into account the effects of long-term operation of this system on intra- and interassemblage variability. Given the emphasis in Hard's model on seasonal variability in mobility modes, perhaps the most important factor affecting assemblage variation is the reoccupation of sites. Aspects of Hard's model suggesting that mobility strategies be viewed as adaptational responses to seasonal and environmental-specific resource congruency problems have implications—on an empirical level—for patterns of site reoccupation and interassemblage variability. It may therefore be possible to evaluate, at least partially, Hard's views of mobility during the Mesilla phase using the Border Star 85 data. This possibility is explored below.

Residential Site Reoccupation: Assemblage Size, Assemblage Diversity, and Site Size

To reiterate, summer residential sites under the foraging model are expected to be associated with sources of water and/or the locations of agricultural fields. In other words, they should be located near playas in the central basin and the alluvial fans below the Jarilla Mountains. Long-term use of these two loci is thus likely to result in a great deal of reoccupation. Significant differences in the nature and intensity of reoccupation should exist between central basin playas and alluvial fans, however, and these differences have considerable import for the archeology of the Border Star 85 area.

The amount and spatial distribution of summer precipitation throughout the basin are believed to be independent conditioning factors on foraging patterns. As Hard notes,

> The availability of water, seeds, and rabbits is dependent largely upon the rainfall, but since rainfall is highly variable year to year and storms tend to be isolated, the number of points at which all resources are present will be dependent upon precipitation. In normal or high rainfall years there would be many locations in which all resources are congruent . . . allowing extensive exploitation of the vast basin zone. In dry years, groups may have to travel long distances to find locations . . . in which all resources are present (1983a:12–13).

Thus, it is expected that a considerable number of foraging activities would be spread evenly throughout the basin, with more reliable areas (such as very large playas or those fed by runoff) being the focus of more frequent use. The alluvial fans and runoff-fed playas at the base of the Jarilla Mountains undoubtedly provided a solution to these congruency problems far more frequently and with greater regularity than even the largest central basin playa. This situation, and the fact that agricultural activities—no matter how minimal—were focused on these fans, would ensure high rates of reoccupation and a complex archeological record in these areas.

If subsistence-related activities in the central basin zone were generally redundant from site to site in foraging situations with high residential mobility, assemblage size and diversity might be expected to be a function of group size, length of occupation, and number of reoccupations. For the ¡Kung, Yellen states that "as a general rule, the longer a site is occupied and the larger the number of inhabitants, the greater and more varied will be the activities that occur there" (Yellen 1977:135). As Vierra (1985:66–70) has outlined, site reoccupation among ethnographically known hunter-gatherer groups rarely involves the reuse of actual habitation loci owing to considerations of health and local resource depletion. More common is a pattern in which a general site area may be reoccupied with new habitation areas being placed adjacent to those used previously. The long-term effect of such situations would be a constant increase in site area and, internally, a palimpsest pattern of structurally redundant residential units. The relationship between assemblage size and diversity is expected to be most pronounced among reoccupied sites, and there should be a concomitant increase in site area with these variables when a strong relationship exists.

When a regional view of interassemblage variability is used to focus on the cumulative archeological remains of forager-type adaptations, a confusing picture can emerge. Variability among assemblages can be considerable, and site classification efforts often attribute these differences to functional variability among both residential and nonresidential sites (e.g., residential bases, short-term camps, chipping stations, and hunting camps). In such cases, sites in different classifications are interpreted as components of a logistically organized system. Vierra and Doleman have shown that these "functional" site typologies can confuse behavioral differences with variability introduced by sampling:

> From an archeological perspective, we can view sites and their assemblages as "samples" of human adaptive behavior. These samples will vary in size due to variations in both intensity of occupation and preservation. . . . In cases where sample size alone accounts for most of the variation in the variety and diversity of assemblage content, it is probable that the different assemblages represent different sized samples of the same range of activities. At best, it might be said of such cases that sampling-related and behaviorally conditioned variability are indistinguishable (1984:14).

Vierra and Doleman (1984:14) also point out that the expected relationship between measures of assemblage variety and sample (i.e., assemblage) size approximates a logarithmic one owing to the fact that maximum diversity (or variety) acts as an upper limit. Similarly, Jones et al. found empirically that the relationship of tool diversity to assemblage size is logarithmic, and that

> the relationship between artifact class richness and sample size is pervasive, and that it is easy to be unaware of the fact that changes in artifact class numbers across space or through time may be tracking little more than changing sample sizes (1983:70–71).

All Formative sites documented during the Border Star 85 Phase II survey were used to investigate the relationships among assemblage variety, size, and site area. Although the sample is small (11 cases, including ceramic unknown sites), the relationships among measures of these variables are strong. Diversity or variety was measured by the number of different lithic tool types in each assemblage using the same classifications made during intensive survey (see Chapter 2) with the exception of ground stone implements. Because these tools are almost always fragmentary, only the most functionally specific classes contributed to tool-type counts. For example, if an assemblage contained unknown ground stone, unknown mano, and both one-handed and two-handed manos, only the latter two would be counted in the variety measure. Assemblage size and site size were measured by the total number of artifacts—exclusive of fire-cracked rock—and site size in square meters, respectively. Because the expected relationships are nonlinear, the latter two independent variables were transformed to their logarithmic representations ($\log_{10}x$). Tool variety was modeled as the dependent variable.

Figure 8.10 illustrates that the relationship between tool variety and both assemblage size and site size does indeed approximate the logarithmic expectation. Separate least-squares regression tests yielded quite respectable r^2 values of 0.889 and 0.834 for assemblage size and site size as

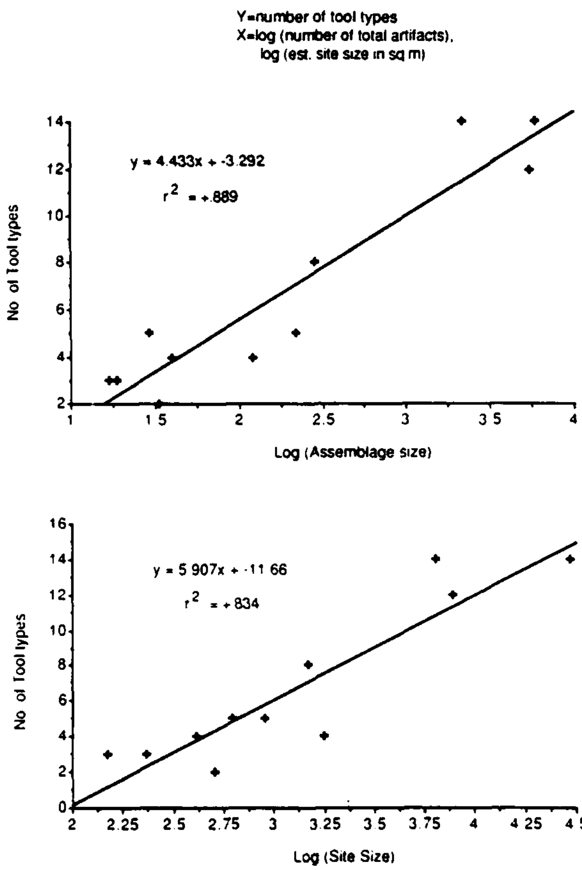


Figure 8.10. Linear regression results: Assemblage diversity vs assemblage size and assemblage diversity vs site size (Formative Period Sites)

Table 8.3. Multiple linear regression results: Assemblage diversity vs assemblage size and site size (Formative Period Sites)

Y=number of tool types
X=log (number of total artifacts),
log (est. site size in sq m)

df:	r^2	Std. Err.:	Coef. Var.:
10	.896	1.636	24.323

Analysis of Variance Table

Source	df:	Sum Squares:	Mean Square:	F-test:
Regression	2	184.763	92.381	34.505
Residual	8	21.419	2.677	$.0001 < p \le .005$
Total	10	206.182		

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	T-Value:	Partial F:
Intercept	-5.784	3.566	-1.622	
Log Artotal	3.354	1.533	2.188	4.789
Log Size	1.584	2.108	.751	.564

predictors of tool variety. When a multiple regression model was applied using these two independent variables, r^2 rose to 0.896 (Table 8.3). An inspection of standardized residuals against the predicted values of this model (Figure 8.11) reveals no patterning and no outlying observations greater than 1.5, thus indicating a good fit. Further confirmation of the adequacy of this linear regression model is evidenced in plots of predicted versus actual values for the dependent variable (Figure 8.11). Correlation coefficients and covariance statistics (Table 8.4) indicate that tool variety is most strongly correlated with assemblage size, followed by site size. Also, the covariance figures for assemblage size and site size indicate that the addition of an interaction term to the regression model would have little effect on results despite the high correlation between these variables.

Of course, the relative strength of these relationships may be affected by the extremely small sample size. If additional data points were available, it is likely that measures of correlation would not be so high, although the basic form of the regression model probably would not change substantially. For this reason, tests of statistical significance are not considered here. Conclusions based on these analyses could indicate that the components of Hard's descriptive model concerning summer residential mobility during the Mesilla phase are consistent with the small amount of data collected during Phase II survey. Given the small sample size, however, these conclusions must be seen as tentative.

Table 8.4. Correlation results

Variables	Covariance	Correlation	r^2
Log (Artifact Total) ÷ Log (Site Size)	0.635	0.937	0.878
No. Tool Types ÷ Log (Artifact Total)	4.134	0.943	0.889
No. Tool Types ÷ Log (Site Size)	2.911	0.913	0.834

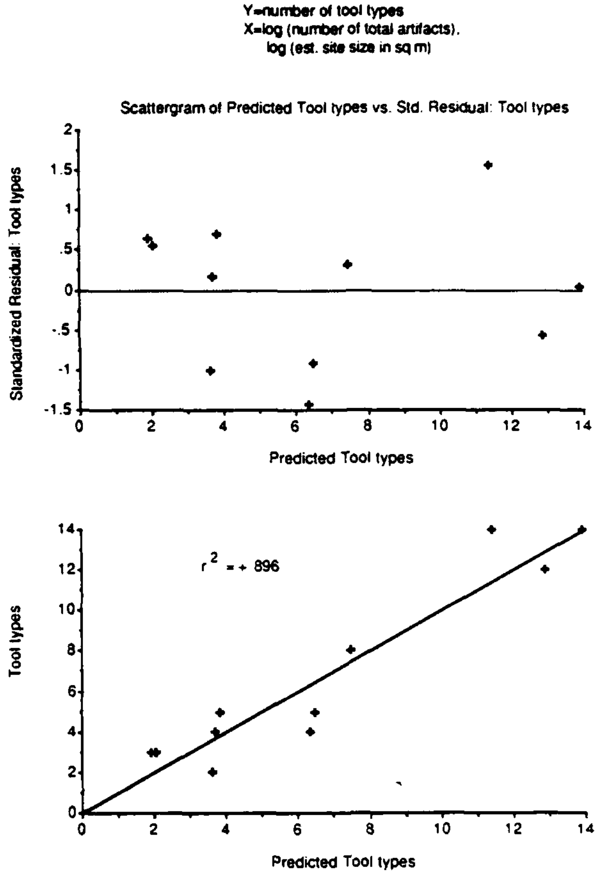


Figure 8.11. Multiple linear regression results: Assemblage diversity vs assemblage size and site size (Formative Period Sites)

Residential Site Reoccupation: Small Site/ Large Site Differences

Other avenues of analysis were pursued that tend to support these interpretations. Assemblage contents were compared between the two largest Formative period sites—LA 62124 and 62125—and the cumulative contents of eight substantially smaller sites from the same general time period (i.e., the Mesilla phase). The larger sites, because of their area and assemblage size, almost certainly represent reoccupied site areas—a residential palimpsest, if you will. In the case of LA 62125, the wide range of radiocarbon dates confirms this interpretation. If the smaller sites are seen as representative of single (or a very few) residential episodes, then their diversity might be expected to vary considerably, but cumulatively their diversity might be expected to approximate that of the highly reoccupied sites. Tables 8.5 and 8.6 present the results of these comparisons.

Although average tool variety for the combined small sites is less than one-third of that for the reoccupied sites, the cumulative total is identical. Differences in the specific

Table 8.5. Tool variety comparisons among Phase II Formative period sites

	Small Site Number								All	Site Number	
Artifact Type	62753	62759	63841	63842	63845	63849	63851	63857	Small Sites	62124	62125
Tested Rock				X			X		X	X	X
Irregular Core	X	X		X	X				X	X	X
Bifacial Core						X			X	X	X
Undir. Core	X								X	X	X
Hammer Stone	X	X		X		X	X	X	X	X	X
Anvil										X	
Ret. Ang Debris	X								X	X	X
Ret. Flake	X						X		X	X	X
Proj. Pt.	X				X				X	X	X
Biface										X	X
Uniface	X							X	X	X	X
Unk. Grd. Stone								X	X		
Unk. Mano					X	X	X		X		
1-Hand Mano	X		X	X					X	X	X
2-Hand Mano											X
Unk. Metate		X	X		X				X		
Slab Metate						X	X		X	X	X
Basin Metate	X			X					X	X	X
Trough Metate										X	X
Total Tool Types	9	3	2	5	4	4	5	3	15	15	15
Assemblage Total	288	17	34	222	121	40	30	19	771	2184	5958
Site Size	1492	236	518	622	1781	415	905	151	6120	6484	29858
Flake:Core Ratio	18.36	3.00	—	12.00	22.67	25.00	20.00	—	18.40	32.32	28.79
Lith:Cerm Ratio	0.108	0.417	2.091	5.529	0.635	0.143	0.071	0.056	1.580	1.411	1.158
Artifact Density	0.321	0.174	0.077	0.429	0.077	0.328	0.070	0.159	0.130	0.608	0.235

constellations of tools among the small sites are considerable, but with very few exceptions, all contain ceramics, debris from lithic reduction (cores and hammerstones), and grinding implements. Substantial differences in flake-to-core ratios are evident, but this pattern is just as likely to be a function of use intensity and distance from raw material sources (see Chapter 7) as it is to result from functional differences. The differences in artifact density may also be due to these factors.

Some functional divergence between sites located on the alluvial fans and those in true central basin contexts might be expected owing to the occurrence of agricultural activities in the former locations. This difference would be revealed in comparisons of ground stone and ceramic assemblages. Items of ground stone commonly associated with intensive processing of agricultural produce (two-handed manos and trough metates) are present only on heavily reoccupied sites located on the alluvial fans (Table 8.5). In a similar vein, ceramic diversity—in terms of both type and vessel form—appears to be greater in the reoccupied sites and in LA 63490, on the uppermost portion of the alluvial fan. Here again, though, one must consider variation in group size, length of occupation, and the number of reoccupations as determinants of site content. These particular ground stone artifacts are rare, and they probably were not discarded on every one or even a majority of the residential sites. In any event, the sample of Formative period sites considered here is highly biased toward the alluvial fan zone. Only three small sites in Survey Units 5 and 6 are located in the basin floor, thus precluding any meaningful comparisons of assemblage content that might support or refute the occurrence of this kind of functional difference.

Also problematical is the fact that the heavily reoccupied sites may represent use over a period of 1000 years or more. If the generally recognized trends toward increased dependence on agriculture in the Jornada Mogollon region hold true, the use of runoff zones below the Jarilla Mountains is likely to have changed considerably during this period. Without a means of monitoring and controlling for

Table 8.6. Summary of tool variety comparisons among Phase II Formative period sites

	Reoccupied Sites		All Small Sites		
Variable	LA 62124	LA 62125		Mean	s
Total Tool Types	15.00	15.00	15.00	4.25	1.83
Assemblage Total	2184.00	5958.00	771.00	96.38	104.79
Site Area	6484.00	29858.00	6120.00	765.00	590.54
Flake:Core Ratio	32.32	28.79	18.40	16.84	8.10
Lith:Cerm Ratio	1.41	1.16	1.58	1.13	1.90
Artifact Density	0.61	0.24	0.13	0.20	0.14

such change on these large sites, it is not possible to distinguish analytically between interassemblage variability resulting from sampling effects and that created by human adaptive behavior.

Nonresidential Activities

Although Hard's model explicitly excludes nonresidential components from consideration, they are of interest here. Problems with the recognition and interpretation of less visible cultural remains are crucial to an understanding of those more concentrated remains commonly recognized as sites. In any given environmental setting, distributions of isolated artifacts reflect functionally specific kinds of activities that complete the partial adaptational picture provided by residential sites. Efforts are made here to explore ways of looking at and interpreting isolated artifacts.

Within the Border Star 85 project area, nonresidential activities are probably represented by cultural remains with low visibility that were only in rare instances defined as sites. In the context of the basin floor environmental zone, it seems likely that these components would reflect extractive activities focused on plant or animal resources, which have essentially ubiquitous spatial distributions. The pattern of summer seasonal use proposed by Hard for the basin floor zone involves the exploitation of seed resources, such as mesquite and grasses, and rabbits—both of which are distributed more or less evenly throughout the basin and are most abundant during the summer months (Hard 1983a:11–12).

Based on extensive survey data from portions of the Tularosa Basin south of the Border Star 85 project area, Carmichael offers similar interpretations concerning the nature of Mesilla phase use of the basin floor, with special emphasis on mesquite exploitation:

> Thus, the southern Tularosa Basin and Hueco Bolson may be seen as a *resource zone* which was targeted primarily for seasonal exploitation.... The most permanent sites, probably occupied through the winter at least, could be expected to occur along the Rio Grande and possibly in other areas of permanent water. The interior basins would most likely be utilized during the summer, when their relatively homogeneous biotic resources are most productive (Carmichael 1981:65).

From the perspective of individual episodes, extractive activities of this sort at any given locale would be expected to be of short duration and would contribute only minimally to a visible archeological record. This situation is further complicated by the very active nature of biological and geomorphological processes in the basin floor.

Taking a long-term perspective on extractive activities provides a somewhat different picture. An archeological record of hundreds or thousands of years of extraction, combined with the operation of natural formation processes, should present an expansive and more or less continuous distribution of low-density remains that is difficult or impossible to partition for study using traditional site-oriented methods. This kind of cultural landscape can be expected to represent mixed and overlapping artifact distributions resulting from a large number of use episodes of unknown cultural/temporal affiliation.

In contrast to the relationships outlined previously for residential sites, assemblages from nonresidential components would not be expected to exhibit a strong relationship between diversity and numerical size with increasing reoccupation. If basic patterns of extractive activities remain unchanged, repeated use of an area would contribute to an increase in assemblage size without increasing assemblage diversity or variety.

Phase II of the Border Star 85 survey collected information relevant not only to archeological sites but also to these less visible components of the cultural landscape. The remains of both sites and isolated occurrences are considered here in light of these expected relationships. Assemblage size and diversity measures identical to those used in the previous analysis were applied to the combined site and isolated occurrences assemblages for five of the six Phase II survey units. Unit 4 was omitted from this analysis because it was located entirely within a single site.

Figure 8.12 illustrates the relationship between assemblage size and diversity for sites and isolated occurrences in these five units. Although the small number of observations considerably limits interpretation, the difference

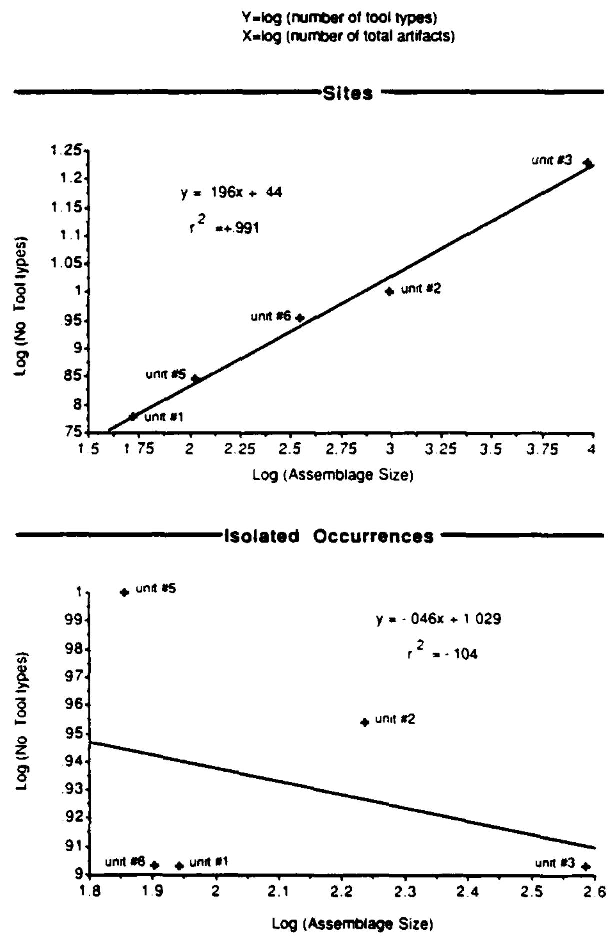


Figure 8.12. Linear regression results: Assemblage diversity vs assemblage size

between sites and isolated occurrences is pronounced. As demonstrated previously for Mesilla phase sites, assemblage size and diversity for all site assemblages are positively correlated (Pearson's r = +0.996), and the linear regression indicates a perfect relationship with a value for r^2 of 0.991 when expressed in log form (Table 8.7). In contrast, there is essentially no relationship (Pearson's r = −0.323) between these two measures for the isolated occurrences (r^2 = 0.104; Table 8.7). Apparently, when isolated occurrences are expressed as assemblages from sampling units of identical sizes, they are categorically different from sites in terms of the diversity versus sample size relationship. Larger samples of isolated occurrences do not yield increasing numbers of different tool types.

In spite of sample size limitations, it is suggested that the difference between sites and isolated occurrences in terms of artifact diversity reflects very different kinds of behavior. If sites represent varying sized samples of the same set of residential activities, owing to varying use intensity, then isolated occurrences might be seen as the cumulative remains of a more limited and, presumably, task-specific, set of activities. It is concluded that further exploration of assemblage size versus diversity relationships in both site and isolate distributions would be a productive approach toward understanding Formative period adaptations in the Tularosa Basin and Hueco Bolson.

Table 8.7. Linear regression results: Assemblage diversity vs assemblage size

Y=log (number of tool types)
X=log (number of total artifacts)

Sites

df:	r^2	Std. Err.:	Coef. Var.:
4	991	.019	1.959

Beta Coefficient Table

Parameter	Value:	Std. Err.:	Variance:	T-Value:
Intercept	.44	.03	.001	14 898
Slope	.196	.011	.0001138	18.392

Analysis of Variance Table

Source	df:	Sum Squares:	Mean Square:	F-test:
Regression	1	.12	.12	338.255
Residual	3	001	.0003547	p ≤ 0001
Total	4	.121		

Residual Information Table

SS[e(i)-e(i-1)]:	e ≥ 0:	e < 0:	DW test:
002	3	2	2.11

Isolated Occurrences

df	r^2	Std. Err.:	Coef. Var:
4	104	.048	5.115

Beta Coefficient Table

Parameter	Value	Std. Err.	Variance:	T-Value.
Intercept	1 029	165	027	6 25
Slope	- 046	.078	006	- 592

Analysis of Variance Table

Source	df:	Sum Squares:	Mean Square:	F-test:
Regression	1	001	001	35
Residual	3	007	002	p > 25
Total	4	008		

Residual Information Table

SS[e(i)-e(i-1)]:	e ≥ 0:	e < 0:	DW test:
018	2	3	2.698

Summary

The analyses of Phase II survey results conducted in this chapter have focused on two major problem domains:

1) The identification and chronological placement of Preformative and Formative period remains as reflected in the Phase II sites, and

2) The consideration of Phase II survey results in light of Hard's (1983a) model of Late Mesilla phase subsistence and land use.

Analytical efforts concerning the identification and chronological placement of Preformative remains were complicated by several factors. Perhaps the most important were the limitations imposed by the extremely small sample confidently dated to this period (six Phase II sites) and the possibility of buried deposits in Survey Units 3 and 4 on the alluvial fan. Other limiting factors included the lack of chronologically sound projectile point sequences for the Tularosa Basin and Hueco Bolson—a subject considered in more detail in Chapter 15—and the lack of unambiguous methods for using lithic technology "signatures" to distinguish pre-Formative from aceramic Formative sites. When lithic technology dating techniques are used, ambiguities arise because the techniques fail to control for possible variation in site function and occupational history. Although the sample size restrictions precluded a detailed consideration of this problem for Preformative remains, site function and reoccupation are dealt with in the context of the second problem domain mentioned above.

When compared to assemblages from Formative period sites, Archaic assemblages in the Phase II sample generally conformed to patterns documented elsewhere in the Southwest involving reduction techniques and raw material preferences among Archaic populations. The possibility that variation in lithic raw material availability within the survey area might be at least partially responsible for these patterns was suggested, however.

The identification and chronological placement of Formative period sites were also subject to ambiguities arising from reoccupation and, to a lesser degree, small sample size. Based upon both radiocarbon dates and ceramic evidence, the majority of the Formative period assemblages were from sites that reflect use throughout the Mesilla phase. In general, ceramic assemblages from Mesilla phase sites were consistent with the few radiocarbon dates that were obtained, both in terms of diagnostic ceramic types and El Paso Brown rim measurements.

Considerable room for error in ceramic dating was found in the case of LA 63490, a site that appears to have a classic Doña Ana phase ceramic type assemblage. A more detailed inspection of the Mimbres Black-on-white ceramics in this assemblage (which revealed the presence of Styles I and II) suggests Late Mesilla phase use of the site as well as Doña Ana phase occupation, as indicated by the presence of painted El Paso Brownwares and Chupadero Black-on-white. Rim sherd measurements for El Paso Brownwares were also found to be ambiguous. No statistically significant differences were found in comparisons between plain brown rims from two Mesilla phase sites—one of which had radiocarbon dates—and the sample from

the alleged Doña Ana site (LA 3490). It can be concluded that the ceramic assemblage from LA 63490 is likely to be mixed and probably represents several reoccupation events during the Mesilla and Doña Ana phases. Actual locations of residential occupations during those times may lie outside the 100 by 100 m area surveyed during Phase II.

The current convention of dating Doña Ana phase sites using ceramic data from surface contexts is thought to be unreliable, especially at large reoccupied sites where associations are unclear. Ceramic dating of well-defined midden features is possibly less prone to error, as Carmichael (1983) has suggested, but the technique is restricted in use to sites containing such features and will surely bias our understanding of the Doña Ana phase. Middens are by far most common in extensive and dense sites, which were probably created by high use intensity and reoccupation, and it is highly unlikely that such sites constitute the only Doña Ana phase remains in the Tularosa Basin and Hueco Bolson.

Even in these large sites, the diagnostic ceramic types needed to distinguish this phase from the Mesilla or El Paso phases rarely represent more than 1 percent of the total ceramic assemblage. Although El Paso Plain Brown rims occur with considerably higher frequency, their utility in chronological control has yet to be established. As outlined in Chapter 13, brownware rim dating has considerable potential for solving this problem, but is still in its methodological infancy. Smaller Doña Ana sites are thus likely to be mistakenly placed in the Early or Late Mesilla phases (or in a ceramic unknown category) because sampling reliability may be very low for these rare ceramic types.

Given this possibility, one must question settlement pattern studies, such as Carmichael's (1983), which place considerable import on the fact that most Doña Ana phase sites are concentrated in certain environmental zones and are generally larger than earlier Mesilla phase components. The patterns perceived by Carmichael may indicate our inability to date small components accurately in addition to reflecting pronounced and rapid shifts in subsistence strategy during the Transitional Pueblo phase. A more complete and balanced view of this crucial phase is needed, and biases in our ability to identify and study all of its components must be removed before we can obtain that view.

The second analytical domain focused on Hard's (1983a) model of Late Mesilla phase subsistence and land use. Since this model is regional in scope, encompassing a large portion of south-central New Mexico and far west Texas, a certain amount of translation was necessary before implications for the Border Star 85 project area could be derived. This translation involved a consideration of the project area in terms of Hard's environmental divisions along with some modification of concomitant seasonal adaptational modes (mobility patterns, target resources, etc.) inherent in the model. Translation was necessary to relate Hard's behavioral expectations to a series of empirical expectations for the Phase II data. Also, because this model is essentially static and does not account for the operation of site formation processes in its expectations for interassemblage variability, several additional concepts were introduced that allowed some evaluation using the Border Star 85 data. These concepts concern the cumulative effects of residential and nonresidential mobility and site reoccupation on assemblage size and diversity.

The basic implications of the model for the Border Star 85 project area revolve around the expectation that Late Mesilla phase groups relied upon a seasonal strategy of mobile foraging in the basin floor with minimal investment in agriculture in runoff situations on alluvial fans. Because of the discrete distribution of water in these two areas, and the ubiquitous distribution of other kinds of resources throughout the basin during the summer months, reoccupation of sites or site areas is expected to be common. It was suggested that the long-term effects of situations involving high residential mobility and reoccupation on interassemblage variability would be reflected in a strong positive correlation among site size, assemblage size, and assemblage diversity within the 11 Formative period sites documented during Phase II. Consequently, the variety and number of items entering the archeological record at a given site would be a function of use intensity (i.e., length of occupation, number of occupants, and number of reoccupations). The results of correlation and regression analyses were found to be consistent with this expectation of use intensity. Both site size and assemblage size were excellent predictors of tool variety for this small sample when expressed in log-linear form.

It was also suggested that nonresidential or limited activity sites would, as a group, exhibit no relationship between measures of assemblage size and variety. That is, continued use or reoccupation of an area such as the basin floor for task-specific purposes is likely to increase the number of items in an assemblage without adding significantly to its diversity. Since it was assumed that isolated artifacts would be most likely to reflect limited and probably simple extractive activities, these artifacts were divided into five groups representing the five survey units. For the sake of comparison, the same was done for site assemblages within those survey units without regard for chronological control. When expressed in log-log form, the relationship between assemblage size and the number of different tool types was perfect for the five site groupings, while their nonsite counterparts exhibited no relationship.

The implications of these analytical results probably have more to do with methodology in general than with the specifics of Hard's model. Although these results are consistent with the basic expectations of the model regarding the nature of Mesilla phase use of the basin floor environment, severe sample size restrictions preclude any firm statistical or behavioral conclusions. More important are the implications for recent settlement pattern studies in the Tularosa Basin and Hueco Bolson. The basic message of these analyses is that we should be aware of the possible effects of variation in sample (assemblage) size on site contents. When sites vary greatly in areal extent and in the sheer magnitude of their contents, it is difficult to justify site typologies that divide sites into residential versus non-residential or village versus camp divisions, as has been done in most survey-based research in the region.

The use of definitional approaches to site function by both Whalen (1978) and Carmichael (1983) utilize variously combined measures of site area, assemblage size, and assemblage diversity to divide sites into residential and nonresidential types. As Mauldin notes, the results of these efforts have been inconsistent:

> The definitions utilized by Whalen and Carmichael are both reasonable, yet in the same data set there is a discrepancy of 88 sites using the two different recognitional criteria. The fact that two plausible definitions can generate such disparate results suggests that the recognition of site function by definition is not the most productive procedure given our present understanding of the factors which condition site variability (1984:13).

If Hard is correct in saying that Mesilla phase adaptations were based on seasonal foraging in basin floor environs—and there is general agreement among all researchers on this point—it makes little analytical sense to continue use of the residential vs nonresidential dichotomy in settlement pattern studies of this region during this period. Yellen's suggestion based on ethnoarcheological research of ¡Kung residences is worthy of serious consideration in this regard:

> When sites are compared on the basis of their contents, I suggest a single scale, ranging from simple to complex, may prove more useful than a typological approach that posits, a priori, discrete and often named categories (Yellen 1977:135).

Differences in site function during the Formative period are certainly expected, but true functional differences, that is, differences in the functional role of sites in an organizational sense, are likely to reflect seasonal variations in adaptive behavior and be evident on a geographical scale broader than that which has been considered in any single survey of the Tularosa Basin or Hueco Bolson.

The view taken here that site assemblages represent varying sized samples of a consistent set of residential activities has considerable implication for purely chronological concerns. Virtually all nonchronometric dating methods (and especially ceramic type dating) rely on relatively rare items of material culture. It should be expected that the probability of a rare item being discarded or otherwise left at a given site will, to a large extent, be a function of use intensity. Put simply, small sites resulting from low levels of use intensity are unlikely to contain rare items. When the presence/absence of late, relatively rare artifacts is used to distinguish between earlier and later sites, as is the case for Doña Ana phase remains, smaller sites will tend to date earlier than larger, more intensively used or reoccupied sites. Faced with settlement patterns resulting from such chronological assignments, most archeologists would find it difficult to resist an interpretation positing a sudden temporal trend toward regional aggregation of population, increased sedentism, and so on. It is for this reason that the development of dating methods utilizing more common artifact types, such as brownware rim analysis, is seen as crucial.

Chapter 9

SUMMARY AND CONCLUSIONS

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Introduction

As discussed in a number of preceding chapters, the Border Star 85 project presented us with an intriguing challenge because of an inherent tension between the research objectives of the project and the methods which had been designed to gather data to achieve those objectives.

Stated simply, the research questions guiding the project were phrased as a set of seasonal settlement propositions for different phases of occupation of the Tularosa Basin/Hueco Bolson region, which derived from a cultural-ecological theoretical framework. Implicit in those models were expectations that the archeological record of the region could, through application of appropriate discovery, documentation and analysis methods, be characterized as a set of site types reflecting different seasonal components of phase-specific settlement behavior.

The methods proposed for the survey consisted of a systematic transect sample, infield analysis of all features and artifacts within transect recording units, and post-facto analytical definition of site assemblage content.

The first stage of our research was totally involved in fine-tuning and implementing the transect based data recovery method. This task in itself constituted a major challenge because of infield computerization and reporting needs, large field crew size, and the fast track nature of the project. Details of that process are discussed in Chapter 2 and Appendices 1 and 2.

As the survey fieldwork and analysis progressed, however, we began to have nagging doubts that the transect sample method was capable of providing assemblage data across enough site locations to adequately evaluate the seasonal settlement propositions guiding the project. By the time Phase I fieldwork was concluded, we realized that a major focus of our research had to be directed precisely at that question. Was the TRU sample method adequate for gathering data to address the research domains? In order to assess the accuracy and precision of the Phase I survey method in characterizing the surface distribution of artifacts and features, the Phase II survey was designed explicitly to provide such data for a sample of distribution types. Results of that assessment are treated in Chapters 5 and 6, and in essence verified our fears: The Phase I TRU method was not a reliable estimator of assemblage content at the site-specific scale of resolution. The method, heretofore untested, indeed was divorced from the theory underlining the project.

Having established that the Phase I survey method was not providing assemblage data reliable enough to evaluate the site specific propositions concerning seasonal settlement models for the basin, we then turned to the Phase II data, which had been gathered at a very fine grained (2 × 2 m) scale of resolution across 39 site locations. Through this analysis (Chapters 7 and 8) the awful truth concerning the other side of the method-theory equation began to emerge: the empirical character of the site locations themselves did not fit implicit expectations embedded in the seasonal settlement models. Whereas the models implicitly assumed that many if not most sites should reflect phase-specific occupations, the site locations frequently dated to more than one phase. Whereas the models assumed that variation in site size and artifact density could be used as direct measures of residential group size and duration of occupation, the site locations were rather demonstrated to vary in size and density due to multiple occupational events. Finally, while the models assumed that internal variation in the surface-visible distribution of artifacts and features at site locations provided information about the prehistoric use of site space, it became obvious that much of the apparent surface patterning was conditioned solely by soils morphology.

Having conquered our fear of methodological inadequacy at this juncture, we were plunged into the loathing of theoretical frustration. Not only were the methods proven inadequate to evaluate the theory, the theory itself was premised upon false assumptions. This situation pointed to a single path of resolution, however, which was that of embarking upon a process of theory building. We hope we have taken some tentative steps in that direction with this volume.

The intent of this chapter is to review the results of the Border Star 85 project, and to discuss their implications for archeological research in the Tularosa Basin/Hueco Bolson region. These discussions are grouped into sections based on the major problem domains addressed by the Border Star 85 project. First, analytical objectives concerning identification and chronological placement will be considered in light of research results from chronological studies outlined in Chapters 10–13 and 15–17. Second, the results of Phase II analyses will be discussed both from the perspective of Hard's (1983a) model of subsistence and land use during the Late Mesilla phase, and in terms of the problem of residential mobility and site reoccupation (Chapter 8). The subject of data collection methods will be addressed in the third section using the results of calibration efforts (Chapters 5 and 6) as a basis for recommendations for future survey in the Tularosa Basin/Hueco Bolson region. Considerations of surface visibility of archeological remains and implications for interpretation are addressed

in a fourth section. Finally, a discussion of problems in the assumptions underlying current models of prehistoric settlement and subsistence systems is developed.

Chronology and Phase Identification Problems

The bulk of archeological research in the Tularosa Basin/Hueco Bolson has been based on surface survey observations rather than excavation data. Very large tracts of land on the basin floor have been surveyed in the last decade, and thousands of sites have been documented at varying levels of detail. The number of sites known through even minimal amounts of excavation, however, are a very small fraction of the total number documented. Due to this lack of chronometrically dated material, archeologists are faced locally with absolute and relative chronological problems that have been more fully resolved in other regions of the American Southwest. Thus, for the Tularosa Basin/Hueco Bolson, refining regional chronology and establishing descriptive baseline data characterizing different periods of occupation still constitute primary research objectives.

These problems arise in part from the nature of the region itself, in that site visibility is hampered by very active geomorphological processes on the basin floor. It is difficult, for instance, to identify consistently the architectural features that are expected to exist at sites and to render them useful as cultural/temporal markers. Active erosional processes also ensure that intensively reoccupied sites will frequently contain temporally mixed assemblages that are difficult to separate on the basis of diagnostic artifact classes or spatial patterning of artifacts.

Chronology and identification problems have been addressed in this report from three directions. The first involves the use of chronometric methods—in this case, radiocarbon and obsidian hydration dating techniques (Chapters 10 and 11). The second approach relies on studies of diagnostic artifacts, such as ceramic typologies (Chapters 12 and 13) and lithic tool typologies (Chapters 15–17). In the third approach, the use of assemblage "signature" methods was explored. These studies focused on aspects of lithic technology and raw material selection and on temporal patterning in ceramic vessel form as potential chronological tools (Chapters 8 and 13).

Prior to the survey it was hoped that the combined use of radiocarbon and obsidian hydration methods would result in the absolute chronological placement of a significant number of the Border Star 85 sites as well as a starting point for other assemblage-based diagnostic approaches. Obsidian was not as common as expected, however, however, and firm associations with radiocarbon dates were not obtained. Although the goal of using this method as the primary means of chronological control was not realized for the Border Star 85 project, the results of the obsidian hydration analyses have made significant steps toward its realization in future research. A previously unrecognized local source of obsidian was characterized through XRF analysis and, provided independently dated samples can be obtained, a hydration curve can be constructed. Induced hydration rates can also be obtained for this source. Radiocarbon studies were also successful in that a considerable range of the Phase II sites were dated and several large sites were recognized as having extremely long histories of use. This latter finding is crucial to the consideration of Formative period subsistence and settlement (Chapter 8).

Charcoal identification studies (Chapter 10) also provided some surprising findings relevant to paleoenvironmental concerns. The identification, in most of the hearths sampled during Phase II, of charcoal from woody species rare or absent in the project area today indicates the need for further paleoenvironmental research in the southern Tularosa Basin. This need is further emphasized by the considerable time depth for some of these species evidenced by the radiocarbon determinations.

Contributions to the refinement of existing chronological methods were made in the area of ceramic typologies. Chapter 12 summarizes the current status of ceramic dating in the Jornada Mogollon region. It is emphasized in this chapter that use of simple co-occurrence criteria of Mimbres Black-on-white with El Paso Polychrome and other types in dating Doña Ana phase remains is problematic in several respects. First, the AD 1150 ending date for Classic or Style III Mimbres is based entirely on the Mimbres Valley sequence, and its use in the Tularosa Basin may not be appropriate without additional independent dates from this area. Also, the AD 1150 beginning date for El Paso Polychrome is based on a single occurrence, and until more dates can be secured it should be considered suspect.

The Doña Ana problem is also approached through petrographic analysis. Analysis of four collections of Mimbres Black-on-white sherds from the Mimbres Valley and the Tularosa Basin/Hueco Bolson (including the Border Star 85 project area) reported in Chapter 14 indicates that, although there appear to have been several manufacturing locales outside of the Mimbres "core area," it is unlikely that any of these were in the Tularosa Basin. Thus, Carmichael's (1983) suggestion that Mimbres ceramics continued to be manufactured locally (i.e., in the Jornada Mogollon region) after the depopulation of the Mimbres Valley in AD 1130–1150 was found to have some empirical support. A considerable amount of additional petrographic research is necessary before the distribution mechanisms of Mimbres ceramics and their spatial/temporal limits are known.

The problem of dating archeological sites in the Tularosa Basin/Hueco Bolson area on the basis of projectile points and other diagnostic tools is also addressed. In Chapter 15 the lack of an adequate local sequence is pointed out as a major stumbling block in the use of projectile point typology. Attempts to use these artifacts for chronological control in the Tularosa Basin have relied on typologies from surrounding regions and have experienced difficulties with forms that cannot be fit into any existing dated types. Border Star 85 projectile points were classified using both statistical and subjective methods, with existing typologies for Trans-Pecos Texas, the Oshara Tradition, and the Cochise Tradition serving as controls. Although the objective methods—involving the use of discriminant statistical techniques—produced somewhat ambiguous re-

sults, several projectile point types that appear to be distinct local forms are identified. Because there is, at present, little absolute chronological control underlying the typology presented here, the results of this analysis should be viewed as preliminary. Toward that end, all of the collected projectile points from the project are illustrated in Appendix 10. One interesting observation drawn from the analysis is the identification of overall trends in point morphology through time that may reflect very broad, multiregional adaptive changes in the use of projectile points.

Chapter 17 considers the use of other forms of lithic tools in chronological studies. As part of a descriptive treatment of LA 63880, a large collection of Paleoindian tools is compared to the larger collection of tools from Phase I survey and to other existing Paleoindian collections from the Middle Rio Grande Valley. This study emphasizes the unique nature of materials dating to this poorly documented time period and their diagnostic value in the Tularosa Basin.

The use of assemblage "signature" methods of chronological control is considered in addressing the problem of identifying Preformative or Archaic period remains on the basis of lithic reduction trajectories and raw material diversity. The analysis of Phase II survey results (Chapter 8) evaluates the widely held belief that Archaic assemblages can be distinguished by the predominance of fine-grained and nonlocal raw material types and debris from more advanced reduction stages and biface manufacture. Although the Phase II data generally support these notions, before these approaches can be used reliably, some consideration must be given to functional and other situational sources of variability in lithic assemblages. Relative distance of site locations from the Jarilla Mountain source, for example, was found to be a dominant controlling factor in technological variation for some materials.

Chapter 16 addresses the problem of distinguishing among formally retouched tools which are rejected during the manufacturing process and those which were completed and actually used. This analysis are critical in establishing locations at which formal tool manufacture was actually undertaken, and distinguishing sites at which utilized tools are lost or discarded.

The use of vessel form for chronological control is also explored in Chapter 13. The Rim Sherd Index (RSI), as described by West (1981) and Carmichael (1983), and rim eversion measures were explored using El Paso Brownware rim sherds collected during Phases I and II of the Border Star 85 survey. Although there is little independent chronological control for the Border Star 85 collections, the changes in average RSI values for the Mesilla, Doña Ana, and El Paso phases are generally in agreement with the figures given by Carmichael and West. What is really being measured, however, are changes in vessel form, and these forms undoubtedly vary in function. As is the case for the lithic "signature" methods, some consideration must be given to possible functional and use intensity differences among sites before the RSI can be used with confidence for chronological purposes.

The chronological and phase identification studies reported here underscore the need for the concerted development of absolute and relative chronological approaches using both survey and excavation data. A balanced approach is necessary, but from the perspective of survey, the development of obsidian hydration and assemblage signature techniques is most crucial. The present level of our knowledge in the Tularosa Basin/Hueco Bolson dictates that excavation and the judicious use of chronometric dating techniques will be required to reduce present levels of ambiguity in chronological methods.

Evaluation of Seasonal Settlement Models: A Consideration of Site Reoccupation and Residential Mobility

The results of Phase II survey formed the basis for two very different analyses. The sampling and resolution questions raised by the data collection methods used during the Phase I survey are reviewed in the following section of this chapter. Consideration in this section is given to the results of analyses aimed at evaluating Hard's (1983a) model of subsistence and land use during the Late Mesilla phase, presented in Chapter 8. This evaluation is offered as a preliminary consideration of the model's central elements, and it is based on a very small sample of sites.

Perhaps the major contribution of this analysis is the translation of Hard's regional model to the more specific, local level of the Border Star 85 project area. The project area was considered in terms of Hard's regional environmental divisions and their concomitant seasonal adaptation modes. An attempt was also made to relate the behavioral expectations of the model to a series of empirical expectations and implications for the Phase II data. In this regard, the concepts of residential and nonresidential mobility were seen as crucial elements of Mesilla phase adaptations, and an attempt was made to derive from Hard's model a series of expectations appropriate to the nature and limitations of the Phase II site assemblage data.

The cumulative effects of residential and nonresidential mobility on assemblage size and measures of diversity are considered in Chapter 8, based on previous research by Vierra and Doleman (1984), Vierra (1985), and others. The expectation that Mesilla phase use of the basin floor relied upon a seasonal (summer) strategy of mobile foraging with minimal investment in agriculture is evaluated from the perspective of site reoccupation and its cumulative effect on site assemblages.

The idea is presented that high rates of residential mobility on the basin floor would result in the reoccupation of areas that solved the problem of congruence among critical resources. Most of these resources are evenly distributed throughout the basin floor environmental zone, but one—water—is seen as having a tethering effect on the location of residential sites and their continued reoccupation. It is suggested that the long-term effects of situations involving high residential mobility and reoccupation would be reflected in a strong positive correlation between site size and assemblage size and diversity within the 11 Formative period sites documented during the Phase II survey. It was expected that variability in overall site size and assemblage size and diversity would be related primarily to the intensity of occupation and the number of

reoccupation events through time. In general, the results of correlation and regression analysis are consistent with this expectation. Both site size and assemblage size are highly correlated with measures of diversity.

It is also suggested that nonresidential or limited activity sites on the basin floor show little or no relationship between measures of assemblage size and variety. Here, continued use of an area for task-specific purposes is likely to increase assemblage size without increasing its diversity. In order to test this proposition, isolated artifacts (assumed to reflect nonresidential, probably extractive, activities) and site assemblages (assumed to represent residential activities) were each combined into five groups based on the Phase II survey units. It was shown that the relationship between assemblage size and diversity was almost perfect for the five site groupings, while the nonsite groups showed no relationship.

Although the results of these two analyses are consistent with the expectations derived from Hard's model, the small size and questionable representativeness of the Phase II site sample precludes drawing any major conclusions. Also problematic is the assumption that isolated artifacts represent nonresidential activities.

The implications of these analyses for archeological research in the Tularosa Basin/Hueco Bolson are critical as they concern the use of site typologies by current seasonal settlement models. These models categorize sites into residential vs nonresidential or village vs camp divisions on the basis of relative site size, density of artifacts or assemblage diversity. These measures have been used in various combinations by Whalen (1978), Carmichael (1983) and others as a basis for interpreting settlement patterns.The results of the Border Star 85 Phase II analysis suggest, however, that factors of reoccupation rather than functional differences account for the perceived variation among such site types. Given this, the validity of settlement pattern explanations based upon such typologies must be reexamined.

Data Collection Methods

In the Border Star 85 survey, novel approaches were taken for both the Phase I and Phase II data collection efforts. In the Phase I survey, the presence of sites was noted in the field, but they were not used as units of data collection, nor were any attempts made to sample sites per se. Instead, quantitative data for three classes of cultural remains—lithics, ceramics, and features—were collected in a system of regularly spaced 2 by 33.3 m quadrats called transect recording units or TRUs. As such, the Phase I data constitute a spatial cluster sample of the underlying cultural landscape (Chapters 2 and 5, Appendix 1).

In Phase II, quantitative data for the same three classes of cultural remains (fire-cracked rock counts were added) were recorded as a two-part strategy. First, archeologists walked the landscape at 5 m intervals for the purposes of discovering as close to 100 percent of the cultural remains present as possible. Second, all discovered materials were documented and provenienced in 2 by 2 m grids, thus providing a locational resolution of 2 m. The resulting Phase II data not only provided high-quality data necessary for the analyses presented in Chapters 7 and 8, but they also served as the basis for comparison with the Phase I data collected from the same units.

In Chapters 5 and 6, extensive analyses were conducted to discover the limitations and advantages of the Phase I methodology. These analyses determined that, due largely to both the extremely aggregated nature of the cultural landscape and the fact that the TRU system is a cluster sampling design, the Phase I data are subject to a considerable degree of imprecision in estimating or predicting landscape content. In fact, the apparent effective resolution of these data, and thus the minimal unit of analysis, is ca. 250-500 m for most classes of data. This figure translates as the precision of the Phase I data.

Another product of these analyses is the discovery that, on the average, the Phase I data underestimate landscape content by ca. 67 percent. In other words, the Phase I data are "seeing" only one-third of the actual cultural remains present. This error constitutes the bias in the Phase I data. In terms of sites discovered, this bias is seen in the number of sites missed by the Phase I survey that were recorded in the Phase II units, and in the general degree of underestimation of site area (Chapter 7). In addition, it is clear that the majority of sites discovered were not sampled well enough to provide reliable estimates of site content. Consequently, sites documented during Phase I were precluded as units of analysis in addressing the site type expectations drawn from seasonal settlement models.

These problems in discovering and sampling small sites were anticipated by the original Border Star 85 solicitation. In Chapter 5 it is shown that the number of missed sites can be at least roughly predicted and is a simple function of site diameter. As a result, it can be concluded that the number of sites missed is also a function of site size. Since the majority of Border Star 85 sites appear to be quite small (65 percent are estimated to cover less than 872 sq m), the expected proportion of missed sites is rather large. It is entirely possible that between 50 and 75 percent of the small sites were missed.

On the positive side, it appears that the Phase I data were successful in demonstrating basic variation in the structure of the distributional landscape in terms of overall density and degree of aggregation present. The Phase II data confirm that the structure of the cultural landscape is a multidimensional continuum ranging from highly aggregated, dense concentrations of cultural remains to low-density areas characterized by varying degrees of dispersion and aggregation. Small sites lie at the latter end of this continuum, and it is at just this point that the distinction between sites and isolated occurrences becomes blurred and uncertain. For denser areas (larger sites) the question becomes one of where to draw the boundaries. Given the tendency of the TRU data to underestimate site area, it seems probable that the unseen portions of sites represent peripheral, low-density materials. Given the nature of the continuum, small sites, peripheral site areas, and isolated occurrences all represent the same thing: the low-density, dispersed end of the structural spectrum. These landscape types are, however, by far the most common in

the Border Star 85 survey area. Thus, it seems likely that not only are small sites underrepresented in the Phase I data, so too are a variety of low-density phenomena.

The 67 percent bias in the TRU sampling system is probably largely a function of the reduced visibility of low-density phenomena and not of aggregation (the effects of the latter factor should average out at some level of resolution). Thus, it can be concluded that the TRU data are biased not only in terms of overall count estimates but in terms of content as well. The apparent differences between isolated occurrence assemblages and sites (Chapter 8) suggest that the Phase I data may not reliably reflect low-density portions of the surface distribution of artifacts and features.

The causes of this problem lie in the varying levels of visibility of archeological phenomena. The fact that the visibility of archeological remains is a function of the intensity with which archeologists inspect the ground has been previously noted (Eidenbach 1982; Wandsnider and Ebert 1984), and archeologists have often remarked on how artifacts appear to "blossom" on the ground when sites are being recorded. An unfortunate aspect of survey methodologies that miss low-density distributions is that they tend to perpetuate the traditional conceptualization of the surface archeological record as primarily a discontinuous one consisting of hot spots (sites) and intervening areas of very low density materials (isolated occurrences). While the existence of aggregation may confirm that the site concept is valid empirically (Chapman et al. 1985), continuity suggests that the site concept has potentially dangerous drawbacks.

These considerations raise important questions, not only about the data collected in Phase I, but about all survey methodologies and their ability to provide useful information.

In *conventional site surveys*, sites are perceived as cultural properties and constitute units of both analysis and preservation. A perennial problem has been defining how to draw site boundaries and how to distinguish between sites and isolated occurrences. The answers to these questions vary widely from one survey to another and obviously have a considerable effect on how low-density materials are treated.

Examples of *systematic transect surveys* include the Phase I portions of both the Border Star 85 survey and the Navajo-Hopi Land Exchange survey conducted by the Bureau of Land Management near El Paso, Texas (Camilli et al. 1986). In this type of survey, the principal unit of data collection is the transect, and no specific attempt is made to record data from sites. In the Border Star 85 survey the presence of sites was noted; in the El Paso survey they were not. In both surveys, the data collected in Phase I were used to classify the landscape by analyzing the transect data from large (500 by 500 m) units. Phase II of these surveys consisted of intensive documentation of several units chosen on the basis of criteria reflecting the range of variability defined by the Phase I analysis. The resulting high-quality data was then subjected to a variety of site-oriented and nonsite analyses.

In the Border Star 85 case, the unit of preservation for compliance purposes was the site, although sites, isolated occurrences and landscapes all received analytical attention. In the El Paso survey, on the other hand, the site concept was strictly avoided and landscapes and distributions formed the principal units of preservation and analysis, respectively.

Principal problems with this kind of survey are two-fold. The calibration analysis presented in Chapters 5 and 6 has revealed serious questions about the *precision* and *accuracy* of transect data derived from aggregated distributions and has shown that a distinct bias exists against low-density materials. The logical basis for using arbitrarily defined (and perhaps poorly sampled) grids as units of preservation has not been well established.

In the *total survey* method, all visible cultural remains in an area are carefully piece-plotted and analyzed in the field. The Seedskadee project in southwestern Wyoming is the principal example of this method, which is "designed to be consistent with the nature of archaeological deposits" (Wandsnider and Ebert 1984:9). Phase II of the El Paso survey described above was conducted using essentially the same methods. In this approach, the artifact (or feature) itself and the landscape in general form the units of analysis *and* preservation. Few archeologists would deny the value of collecting 100 percent data and the preservation of all the archeological materials in a target area. The main problem with this approach is a simple but unfortunate one: cost. For example, a preliminary estimate indicates that, on the average, the manpower requirements of total survey would be in excess of five times those of the Border Star 85 Phase I survey.

The latter two survey types have evolved in the context of a controversy concerning the usefulness of the site concept, i.e., conventional site survey. Both the interpretive and empirical validity of the site concept has been criticized, and it is becoming increasingly evident that the site concept needs reevaluation as a research and management unit. In essence, recent theoretical and substantive contributions to the survey literature suggest that the notion of sites has led to a misperception of both archeological formation processes and the structure of archeological distributions. While this realization has produced stimulating and innovative analytical approaches, it has left cultural resource managers with the very real and difficult problem of developing new units of preservation.

It is not the goal of this summary to suggest the nature of these new units but rather to point out the need for developing new ways of defining and evaluating cultural properties. Given the probability that important portions of the surface distribution are being systematically missed by both traditional and more modern survey methods, how do we define cultural properties? One important question concerns the concept of cultural properties as units of space or groups of cultural remains. This question in turn raises further questions concerning the concept of *association* and its relation to the factors of reoccupation and surface dynamics.

Designating distributions (or the entire landscape, for that matter) as cultural properties may not be realistic in many

cases. The use of large grid units based on transect survey results is questionable because of the sampling problems involved and the fact that they result in arbitrary associations of cultural remains. Developing appropriate property boundaries that truly reflect the nature of archeological distributions must be accompanied by design of survey methods that adequately sample *all* elements of the landscape equally, that is, methods that are unbiased. Biased survey designs can hardly be expected to provide useful information for making meaningful determinations of significance.

Based on the above considerations, it is recommended that future archeological efforts in cultural landscapes like those inventoried by the Border Star 85 project be guided by a multiple-emphasis strategy that combines both conventional questions and the collection and analysis of data designed to help answer these questions. A four-stage program of data collection and analysis is proposed for future work. It is expected that the information retrieved in this process will prove useful for answering the questions raised by both the methodological and substantive portions of this report.

1) *Sampling design study.* A variety of sampling designs can be applied to the data collected in Phase II (and any data collected in further Phase II-type survey efforts) for the purposes of evaluating their accuracy and precision. Potential designs can be chosen for testing on the basis of a review of the sampling literature and considerations of cost effectiveness. Analysis of published and unpublished data should allow the estimation of the relative logistical and manpower costs of implementing various field survey and sampling techniques (Chapter 5; Camilli et al. 1986; McAnany et al. 1984; Wandsnider and Ebert 1984).

The goals of this analysis would be to define the most cost-effective sampling designs to be used for landscape or large area survey, Phase II survey, and site recording. The landscape sampling design will hopefully be capable of yielding reliable sample data from large areas and will exhibit considerably better effective resolution and accuracy than the Phase I TRU data. The second design should answer the question of whether or not high-resolution data such as that gathered in Phase II can be retrieved by sampling. If the answer is yes, the resulting design could be implemented during additional Phase II-type survey. The third sampling design should provide methods for sampling high-density distributions and offer a useful set of guidelines for sampling at the site level both in general and in the site revisitation stage described below. The analysis should include a calibration of the effectiveness of the Phase I TRU data for sampling sites of varying sizes.

These three sampling analyses combined should provide archeologists with important information about cost-effective sampling at different scales and under conditions of varying aggregation and density. In addition, the results of the work would be valuable to the entire archeological community.

2) *Site revisitation.* Because of the poor site content estimates achieved by the Phase I survey, it is recommended that a representative sample of the sites and site areas identified in Phase I be revisited for rerecording. The term site areas refers to areas of high artifact density and to areas of continuous low-density materials encountered in the Phase I survey that were difficult to divide into sites.

Although choosing a representative sample based on biased data represents a paradox of sorts, the results presented in Chapter 5 and 6 suggest that an analysis of data from large units (e.g., 1–2 sq km) might provide a useful means of stratifying the cultural landscape. Assuming at least some degree of correlation, a representative sample of landscape types, such as those defined by the cluster analysis in Chapter 5, should provide a representative sample of site types.

The principal goal of this stage of resurvey is to increase our knowledge of the nature and content of the sites—or aggregates of cultural remains—in the Border Star 85 area. In its optimal form, this stage would overlap considerably with the next one.

3) *Continued Phase II survey.* The nature of this stage will depend in part on the results of the sampling analysis stage. If it is determined that high-quality and high-resolution data such as that gathered in Phase II can be effectively approximated by sampling, then this stage and the previous one should be essentially the same. If not, it is recommended that more Phase II survey be performed to add to the extant high quality, baseline data provided by the original Phase II survey. As the results presented in Chapter 8 demonstrate, a wealth of valuable information can be achieved with this form of data collection. In addition, this stage—in its 100 percent form—should be directed toward increasing the sample of landscape types as defined in Chapter 5. Only four of the 18 landscape types were visited in Phase II, and the six units visited represent less than 0.7 percent of Area A. In either case, if the sample of units investigated is carefully chosen, the results of this stage should increase our knowledge of both landscape variability and the nature of the archeological record in the Border Star 85 area.

4) *Excavation.* This stage should be the last, since the choice of areas to be excavated should be based on the results of the others. Among other considerations, the results of the first stage should be extremely useful in the likely event that sample excavations in large areas are required. Perhaps the most important goal of this stage will be to yield high-resolution archeological data with the kind of chronological control that is lacking in most of the Phase I and Phase II data. Studies of regional settlement and subsistence must be based in part on well-dated assemblages of artifacts and features whose association is based not on unwarranted assumptions about surface dynamics and spatial association but on demonstrable stratigraphic context.

Data retrieved through excavation should also provide information pertinent to determining the relationship between surface manifestations and subsurface phenomena. Important questions concern the degree to which surface data successfully detect the architecture, features, and assemblage content of the subsurface archeological record. A valuable adjunct to this research would be a study of geomorphological processes in the Border Star 85 area and their effects on archeological visibility.

In addition, careful excavation of extensively reoccupied sites may help unravel questions concerning both the effects of reoccupation on surface assemblage content and the actual nature of the reoccupations. Although archeologists continue to acknowledge the problems associated with the interpretation of multi-occupation assemblages, concerted research addressing the issue has not been extensive. Excavation data can contribute to rectifying this situation.

The program described above is expected to prove useful to archeologists in general, while forming the basis for a responsible cultural resource management program for the Border Star 85 area in the event of future military exercises. The data gathered will be easily amenable not only to the behavioral questions raised in this report but also to the procedural ones. An important aspect of the program lies in the fact that the first stage of sampling analyses *requires no further survey* and provides an important framework for the others. As such, it is possibly the most critical stage. Without it, the data collection stages would be seriously affected by the use of uninformed sampling methods. Finally, it is hoped that a research program of this sort will provide a much needed contribution to contemporary cultural resource management by helping to answer the questions raised here about sites, units of preservation, and data collection methods.

Problems of Surface Visibility in the Tularosa Basin

A final research domain can be defined as of paramount importance to future archeological research in the Tularosa Basin floor. This is assessing the degree to which the portion of the archeological record visible on the present ground surface reflects the subsurface content of that record. This particular area of research was not defined as a goal of the Border Star 85 survey, but through the course of the project, it has become increasingly obvious that understanding the geomorphological context of archeological remains in terms of site formation processes and how the surface visible portion of the record relates to subsurface distributions, is a kind of information critical in assessing the validity of any interpretations made survey data.

The Tularosa Basin floor, and the alluvial fans along the lower slopes of the Jarilla Mountains, are both very dynamic geomorphic surfaces. As documented in Chapter 3, much of the basin floor is characterized by mesquite coppice dunes which may be of very recent origin. Archeological materials are visible only in depressions between the dunes themselves, and as demonstrated by the Phase II survey data, the actual distributional structure of those visible remains is conditioned to a great degree by the dune and vegetation cover. Given the fact that present models of past human use of site space tend to assume that variation in the spatial distribution of archeological materials can be interpreted to reflect past behavior, identifying whether factors such as soils and vegetation are controlling the distribution is an obviously important step in regional research.

The study of surface hydrology of the Jarilla Mountain drainages in Chapter 3 also revealed a surprisingly rapid change in stream channel patterns over a 30 year period from 1954–1984. Clear evidence of stream piracy and channel relocations could be identified through comparison of 1954 and 1984 imagery. The rapidity of these changes needs to be addressed in terms of the potential for buried assemblages in that locale, and from the perspective of settlement models which tend to assume that the locations of present drainage channels reflect prehistoric streams. Indications are that land surfaces in the area of alluvial fans are very dynamic, with at present unknown implications concerning the visibility of archeological materials.

Further evidence of the short-term dynamic nature of the basin floor environment was demonstrated by the Phase II Survey (Chapter 7) in which some site locations documented during Phase I (between October 1984 and January 1985) simply were not visible when the Phase II survey was conducted in July of 1985. These short term changes in surface visibility again have profound implications for interpretations made of settlement patterns which treat frequencies and sizes of sites derived from survey data.

Longer term climatic cycles and their effect upon the soils and vegetation structure of the basin floor are also poorly understood. Species identifications of radiocarbon samples collected during Phase II revealed a preponderance of Juniper, dating between 540 BC and AD 1180. If these identifications are valid (cell structures for Juniper and Mesquite are at times difficult to differentiate), our understanding of prehistoric basin floor food resources may need considerable re-evaluation. Again, most current models of past settlement and subsistence behavior tend to assume that the prehistoric vegetative structure is very similar to the present. Preliminary indications are that these assumptions of uniformity may not be warranted.

In general, it is argued that a much needed next phase of research in the Tularosa Basin/Hueco Bolson should be directed specifically toward gaining a comprehensive understanding of the geomorphological and climatic parameters conditioning soils development, hydrology, and vegetation structure for the basin floors and margins.

Conclusions

We have chosen to subtitle the Border Star 85 Survey report *Toward an Archeology of Landscapes* because we believe the state of research in the Tularosa Basin/Hueco Bolson region now stands at a critical threshold in the development of theoretical and methodological tools. Stated simply, we believe for a number of reasons that conventional conceptualizations of past human settlement behavior deriving from a cultural-ecological approach have reached the limits of their utility in accounting for variation in the empirical archeological record, and must be reassessed. We offer that one direction such reassessment can productively take is that of examining processes of adaptation at a scale of landscapes rather than sites.

For archeologists used to thinking in conventional terms

of the internal variation of ¡Kung San campsites, prehistoric Anasazi rooms of 3–5 m on a side, or artifacts on cave floors piece-plotted to the nearest centimeter, this requires a radical reorientation of concepts of human space-use. The important point to make here is that we believe it is time to begin to develop our models of past behavior at scales of resolution that permit our observations to be used in productive fashion to evaluate them. Models of human settlement and subsistence behavior which require site-specific scales of resolution of artifact distributions on the order of centimeters on the Tularosa Basin floor are not appropriate. The data simply do not retain informational integrity at that fine-grained level of observation.

The archeological record itself, in all its distributional and contextual variety, is the facts. If the concepts of human behavior which we wish to evaluate require specific characteristics of preservation and distributional integrity which make the majority of that record unsuitable for research, then we must seriously question our concepts, not the record. We would argue that the paradigm of cultural-ecological explanation of prehistory in the Tularosa Basin/Hueco Bolson region now stands at this juncture. To be evaluated, the models require that site-specific and phase-specific assemblages be defined; require that intrasite spatial distributions of artifacts and and features be identifiable to scales of resolution of meters rather than 10's or 100's of meters; and require that assemblages of artifacts, (at scales of meters) be unambiguously associated by context with particular features within sites.

Results of the Phase II investigations during the Border Star 85 Survey demonstrate that *none* of these expectations are well met by the Tularosa Basin archeological record. We would argue that a careful examination of the literature documenting excavations within the Tularosa Basin/Hueco Bolson region also demonstrates that these expectations of chronological and spatial association cannot be supported by the data—the archeological facts.

What are the implications of these findings? On the one hand, a simple answer is that many of the questions asked by those proposing cultural-ecological settlement and subsistence models simply cannot be answered. The archeological facts, for the most part, do not meet the requirements imposed by the questions to begin with.

This is not to say the "perfect site" does not exist. Such little Pompeiis *do* exist in southern New Mexico, as they do throughout the world. When encountered, these are exciting and tantalizing case examples of exquisitely preserved features, activity areas, houses, or even portions of larger communal occupations in which the particular spatial relationships of lithic and ceramic artifacts, fire-cracked rock, features and structures have been uniquely sealed into chronometrically datable deposits. Such examples of the archeological record are exceedingly rare, however. The question which must be asked, then, is whether a conceptual approach relying on such fine-grained and idiosyncratic evidence as the sole basis for verifying or repudiating its validity, is reasonable.

In conclusion, we are simply suggesting that a new analytical approach founded upon new concepts of past human cultural behavior and its material by-products must be developed which better accommodates an empirical record characterized by larger rather than smaller scales of resolution. Previous research in the region has provided us with a wealth of data. With appropriately refined conceptual tools, we believe significant advances in understanding prehistoric settlement organization can be made. We hope the results of our research can provide a tentative step in that direction.

Chapter 10

RADIOCARBON DATING AND CHARCOAL IDENTIFICATIONS

Timothy J. Seaman

This chapter presents the results of two separate studies conducted on charcoal samples collected during Phase II survey. First, the results of radiocarbon analysis of 11 charcoal samples by Beta Analytic, Inc., will be outlined. Second, wood species identifications of these same samples performed by William C. Martin, UNM Biology Department, will be described and compared with results of previous paleobotanical studies in the Tularosa Basin/Hueco Bolson and the El Paso areas.

Collection Methods

As outlined briefly in Chapter 2, the locations of charcoal stains visible on the surface were recorded as part of Phase II survey and data collection. After survey of each unit, these stains were revisited by the survey crews and trowel-tested to assess the likelihood that they would yield sufficient charcoal for radiocarbon dating. On the basis of these brief tests, features that were believed to contain sufficient amounts of charcoal were excavated. Eighteen stains (features) were chosen for excavation.

Excavations were restricted in horizontal and vertical extent to the limits of the stains that were apparent after the loose surface sediments were cleared by trowelling. No vertical or horizontal controls were used. During excavation large chunks of charcoal were removed from the stained fill and placed in aluminum foil. In addition, matrix samples averaging 1–2 liters were taken from the darkest fill for the manual extraction of small charcoal pieces in the OCA laboratory. After laboratory processing of the matrix samples, 11 of the 18 features yielded more than 2 g of charcoal and were submitted to Beta Analytic, Inc., for dating.

Dating Results

Table 10.1 presents the dating results in radiocarbon years before AD 1950 and in their calendric equivalents. The latter units are used throughout this discussion. Note that the dates are *not* corrected for fluctuations in atmospheric radiocarbon.

The 11 dates range from 540 BC to AD 1180—a span of 1720 years. Standard deviations range from 60 to 110 years with an average of 77. The dates represent remains in only two of the six Phase II survey units. Sites and isolated hearths in Unit 1, located in the central basin floor, yielded five dates, while two multicomponent sites in Unit 3, on the alluvial fan, yielded six dates.

The dates are almost equally divided between the Preformative and Formative periods, represented by five and six samples, respectively. The Preformative determinations all fall within the Late Archaic phase and represent features from four sites (LA 62126, LA 63883, LA 63884, and LA 63886) and one isolated hearth in Survey Unit 1. Six dates fall within the Formative period: three in the early Mesilla phase (LA 62125, LA 62126, and one isolate in Survey Unit 1) and three in the Late Mesilla phase (LA 62125 and LA 62126). The latest date (AD 1190), obtained from LA 62126, could be considered as falling within the Doña Ana phase (AD 1100–1200) given its 70-year margin of error.

Wood Species Identification

Prior to radiocarbon analysis the 11 charcoal samples were identified as to species by Dr. William C. Martin, Professor of Biology and Curator of the UNM Herbarium and Museum of Botany. This was not a quantified analysis as only the predominant species was identified in each sample. Four species were identified (Table 10.2). Surprisingly, only one of these species—*Prosopis glandulosa* (mesquite)—occurs in the Border Star 85 project area today. The other three identifications are oak (*Quercus* spp./*Quercus harvardii*), juniper (*Juniperus* spp.), and willow (*Salix* spp.). None of these woody species has been reported from the Tularosa Basin/Hueco Bolson or the Jarilla Mountains, but juniper (*Juniperus monosperma*, *J. deppeana*) and oak (*Quercus pungens* and others) occur at somewhat higher elevations in surrounding mountain ranges. It is also surprising that the majority of the samples are oak rather than mesquite, since the latter species is by far the most dominant shrub in the basin today. Almost two-thirds of the samples were identified as either *Quercus* spp. or *Quercus harvardii* (shin oak) in both survey units. The seven oak samples have a date range of 540 BC to AD 1180 (1720 years), indicating considerable time depth for this species in the basin. As can be seen in Table 10.2, the two mesquite samples have an almost equivalent time range (120 BC to AD 1090) and were found in the basin floor (Survey Unit 1) and alluvial fan (Survey Unit 3). Juniper and willow were found only on the alluvial fan and have Early and Late Mesilla phase dates, respectively.

Shin oak and honey mesquite are both adapted to relatively unstable sand dune areas as attested by modern

Table 10.1 Border Star 85 radiocarbon samples

BS #	Lab #	UTME	UTMN	Site #	Unit #	Phase	Species	Age*	s	Date**
4	13638	391928	3587312	62126	3	Doña Ana	*Quercus*	770	70	AD 1180
12	13642	391698	3587034	62125	3	L Mesilla	*Prosopis*	860	60	AD 1090
7	13640	391708	3587026	62125	3	L Mesilla	*Salix*	1250	80	AD 700
2	13637	391924	3587322	62126	3	E Mesilla	*Juniperus*	1600	80	AD 350
13	13643	387432	3597730	—	1	E Mesilla	*Quercus*	1780	90	AD 170
11	13641	391658	3587048	62125	3	E Mesilla	*Quercus*	1800	70	AD 150
17	13646	387288	3597516	63836	1	L Archaic	*Prosopis*	2070	70	120 BC
14	13644	387440	3597788	—	1	L Archaic	*Quercus*	2130	70	180 BC
15	13645	387438	3597840	63834	1	L Archaic	*Quercus*	2260	70	310 BC
6	13639	391940	3587310	62126	3	L Archaic	*Quercus*	2330	80	380 BC
18	13647	387342	3597930	63833	1	L Archiac	*Quercus*	2490	110	540 BC

*in radiocarbon years before AD 1950
**uncorrected AD/BC date

distributions in widespread mesquite coppice dune areas of south-central New Mexico and in the "shinnery belt" zones along the western edge of the Llano Estacado in southeastern New Mexico and western Texas (Leslie 1979). Thus, their use for fuel in the basin floor and alluvial fans of the Border Star 85 project area would be expected. The use of juniper for fuel in Survey Unit 3, located very near the Jarilla Mountains, is also consistent with regional distributions of this species in lower mountain and bajada zones. Intensive mining activity in the Jarilla mining district around the turn of the century could be responsible for the absence of this species today. The moisture requirements of willow suggest that standing water or springs must have been present prehistorically in or around the Jarillas. As outlined in Chapter 3, only one confirmed seep exists in the Jarilla Mountains, but the occurrence of other water sources is suspected on the basis of local geology.

Although only the predominant species was identified in each sample, the results provide information enabling comparison with previous paleobotanical studies in the Tularosa Basin/Hueco Bolson region (Ford 1977; Wetterstrom 1980:25–26) and the Rio Grande Valley near El Paso (Holloway 1983; O'Laughlin 1979:20–21, 1980:79–86). There is general agreement among these charcoal identification studies that mesquite is the dominant species in the vast majority of samples. Table 10.3 summarizes the results of Ford's (1977) studies of charcoal from sites in the eastern Hueco Bolson and El Paso vicinity. Mesquite occurs in ca. 93 percent of all samples and, on the average, constitutes 80–90 percent of the total identified species in each sample. The presence of oak, willow, or juniper as archeological charcoal is not reported in any of these studies. O'Laughlin (1977a) does, however, report significant numbers of acorns (*Quercus pungens*)—presumably used as food—from excavations of two small dry caves west of the Hueco Mountains.

These results have several implications for archeological research in the Tularosa Basin/Hueco Bolson region. The "surprises" afforded by the identifications of *Quercus* and other species presently absent from the Border Star 85 project area indicate that adaptational models whose environmental parameters are based on modern vegetation structure—as most models are, either implicitly or explicitly—may not be entirely appropriate.

Also relevant here are regional changes within the last 100 years that have been documented by range scientists. Research conducted by Buffington and Herbel (1965), Gardner (1951), York and Dick-Peddie (1969), and others indicates that an "invasion" by woody desert shrubs, such as mesquite and creosote, into what was previously desert grassland has affected large portions of southern New Mexico since ca. 1880, an invasion facilitated by overgrazing, fire suppression, and other factors. Although Eidenbach and Wimberly (1980) have shown that the historical data used by York and Dick-Peddie (1969) are of dubious value and that there had been little change in vegetation in some instances, longitudinal studies conducted at the USDA Jornada Experimental Station provide unequivocal documentation of these vegetational changes over a 45-year period (Gibbens et al. 1983; Hennessy et al. 1983).

These relatively recent changes are acknowledged in most archeological research in the Tularosa Basin, but there has been little effort to evaluate their relevance to prehistoric environments and current models of settlement

Table 10.2 Wood species identifications

Species	Number	Percent	Date Range
Quercus spp.* (oak)	7	63.6	540 BC–AD 1180
Prosopis spp. (mesquite)	2	18.2	120 BC–AD 1090
Salix spp. (willow)	1	9.1	AD 700
Juniperus spp. (juniper)	1	9.1	AD 350

*one identification of *Quercus harvardii* (shin oak)

Table 10.3 Occurrence of *Prosopis* charcoal in samples from selected Hueco Bolson sites

Samples	Percent Total Charcoal	Percent of Samples	Number of Samples	Mean Percent	s
Three Lakes Pueblo*	73	92.9	13	79.8	32.9
9 sites**	80	93.1	27	87.4	17.1

*Data from Ford 1977:202, Table E-1
**Data from Ford 1977:204, Table E-2

and subsistence. At this point, uniform assumptions about the vegetation of the basin floor may be risky, and models that posit the exploitation of specific plant resources in the basin floor zone, such as Carmichael's (1981) argument for seasonal mesquite procurement during the Mesilla phase, are based on a very elementary understanding of prehistoric plant communities. Clearly, additional paleobotanical and palynological studies in the Tularosa Basin and Hueco Bolson are in order.

Chapter 11

OBSIDIAN SOURCING AND HYDRATION STUDIES

Phillip H. Shelly, John L. Montgomery, and Kathleen Bowman

Introduction

This chapter presents the results of two separate but related studies of the Border Star 85 obsidian collections performed by Eastern New Mexico University's Obsidian Hydration Laboratory. The first of these reports (submitted to OCA as *ENMU-OHL Technical Report* 85-01) is limited to the characterization of sources evident using XRF data and multivariate statistical techniques on a sample of 45 obsidian artifacts and 3 unmodified nodules collected during the Phase I survey. This source identification study was conducted as a preliminary step toward the development of reliable hydration rate curves for the Tularosa Basin region. On the basis of geochemical variability, these samples were found to be derived from a local Tularosa Basin source and from gravels in the nearby Mesilla Valley.

The second report (*ENMU-OHL Technical Report* 86-01) continued the XRF sourcing study using an additional 61 obsidian artifacts—12 of which were typed projectile points—and 1 unmodified nodule, representing collections made during both Phase I and Phase II surveys. Three additional source locations were identified in this sample: Red Hill (western New Mexico), Los Lunas and Cochiti gravels (Middle Rio Grande Valley), and Polvadera Peak (Jemez Mountains). In addition, geochemical characterization of the local Tularosa Basin source was refined through this study. Hydration rims were measured for most of these samples. Although the samples were not placed in an absolute chronology on the basis of the measurements, it was found that general trends in relative hydration rim thickness were consistent with independent chronological assessments derived on the basis of assemblage ceramic data and projectile point type assignments. The computation of absolute dates for the samples must await the development of hydration rates for these sources.

Characterization of Preliminary Sample

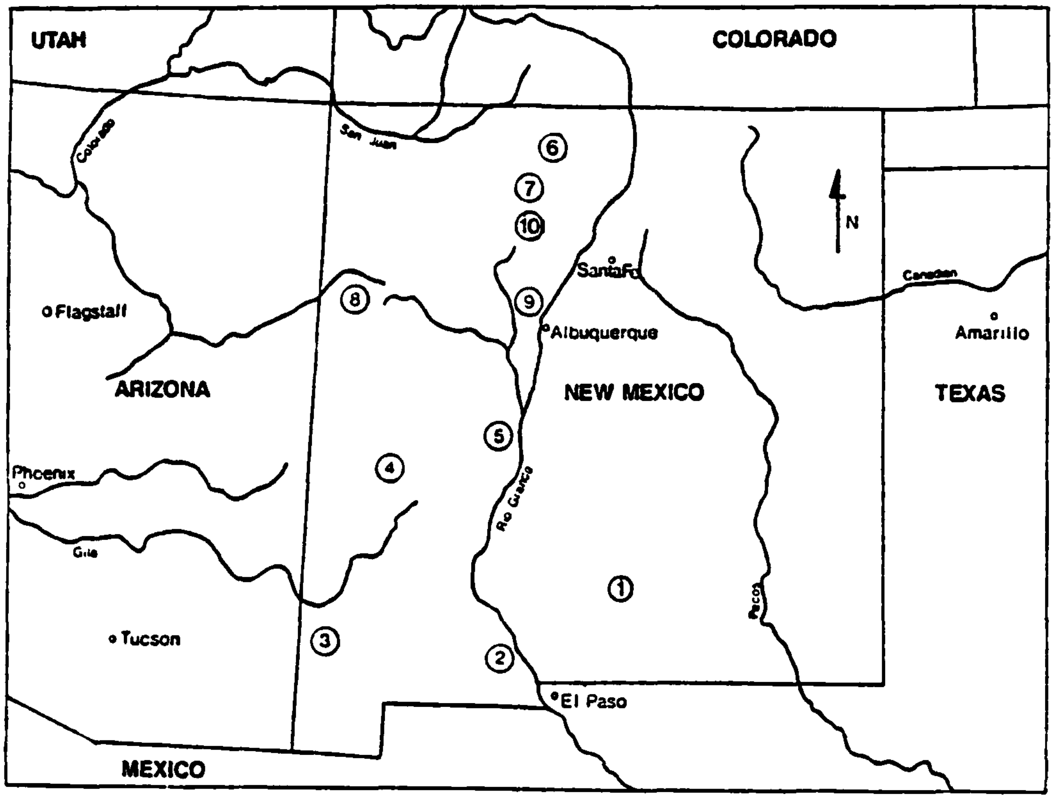
Eastern New Mexico University's Obsidian Hydration Laboratory (OHL) recently completed rapid x-ray fluorescence (XRF) and statistical analyses of 48 obsidian samples submitted by the University of New Mexico's Office of Contract Archeology (OCA). The following report emphasizes two related objectives. First, the XRF data are used to determine the probable source areas for the samples recovered during archeological investigations for the Border Star 85 project. Second, the same XRF data are used to assess the geochemical variability of samples. Both objectives were completed using a multivariate statistical technique (discriminant analysis). Both cultural and natural samples collected by the project were analyzed and then compared to previously collected and characterized source area samples that have been studied over the last five years by the OHL.

XRF Characterization

Geochemical characterization of known and unknown samples was carried out using rapid XRF at the trace element level. XRF analysis is a nondestructive, powerful, and rapid method for determining the chemical composition of materials (Hoffer 1985; Lister 1975). An extensive literature indicates that XRF provides a rapid and economical way of isolating distinct obsidian sources (Dixon 1976; Ericson et al. 1976; Jack 1976; Reeves and Ward 1976; Stross et al. 1976). Rapid XRF can detect the presence of trace elements in as low a frequency as 10 parts per million. This degree of resolution distinguishes among sources that are otherwise similar in major elemental or compound composition. Other investigations of geochemical characterization of obsidians have resulted in similar conclusions (Dixon 1976; Ericson et al. 1976; Jack 1976; Michels and Tsong 1980; Reeves and Ward 1976; Stross et al. 1976). In addition to a fine-grained examination of samples, representative and thorough sampling of source areas is necessary to increase the probability of accurate classification.

Source areas shown in Figure 11.1 were characterized by OHL prior to this project. Many of these samples are subsamples of obsidian used as standards at the University of Idaho Micro-probe Laboratory (Sappington and Cameron 1981), while others were collected by Shelley. In all instances, those samples submitted for XRF characterization were selected because they were considered to be macroscopically representative of a particular geologic deposit or flow. Further, with the exception of the OCA-Tularosa Basin source, no source area was characterized with fewer than five samples. Many sources were sampled more intensively because of their macroscopic variability and their spatial and/or temporal extent.

Three of the samples submitted by OCA were culturally unmodified pebbles of obsidian recovered from the Tularosa Basin (OCA-Tularosa Basin), while the remaining 45 were samples of culturally modified materials from archeological contexts. The three natural samples were used to develop a geochemical profile of locally available obsidian. Neither the genesis nor the representativeness of these samples is known at this time.



Key: (1) Tularosa Basin; (2) Rio Grande Pleistocene terrace gravels, Las Cruces vicinity; (3) Mule Creek; (4) Red Hill; (5) Rio Grande Pleistocene terrace gravels, Los Lunas vicinity; (6) San Antonio Mountain; (7) Polvadero Peak; (8) Grants Ridge; (9) Rio Grande Pleistocene terrace gravels, Cochiti vicinity; and (10) Jemez.

Figure 11.1. Location of obsidian sources used in this study

Methodology

All samples submitted to OCA by OHL were subsampled for XRF analysis at the request of OCA. Subsampling of the material was accomplished by sawing off a small portion for analysis. In the case of archeological samples, care was exercised in selecting a subsample that would represent minimal damage to the artifact and would not preclude future hydration analysis (i.e., rim measurement). The samples were cleaned, labeled, and submitted for XRF analysis.

All samples were powdered prior to XRF analysis to homogenize them and their concomitant XRF values. In addition, powdering provides a relatively uniform target area for x-rays. Consequently, this procedure minimizes variation caused by geochemical changes in the hydrated zone and the underlying material, as well as differences in x-ray values caused by subtle variations in the geometry of the target areas.

The XRF data were generated by Dr. J. Hoffer, Department of Geology, University of Texas at El Paso (UTEP), using an ORTEC Tepha rapid XRF analyzer (Table 11.1). All XRF values were generated and collected using 10 milliamps and 50 kilovolts to a tungsten anode for 200 seconds.

Statistical Analyses

Rather than attempt to compare the geochemistry of known and unknown samples using frequencies of a few "key" elements or a few of the major chemical compounds, we chose to make these comparisons using a multivariate statistic. Discriminant function analysis was selected because it is capable of classifying unknown observations into known populations by considering all known variables and their range of variation within and between groups—in this case, source areas of obsidian. Statistical analyses of XRF data were conducted with an IBM 4331 and SAS DISCRIM programs with default parameters (SAS Institute 1982a, 1982b).

Discriminant function analysis uses either the discriminant variable scores or the canonical discriminant functions to predict the source to which a particular sample most likely belongs. In multivariate space, this procedure

Table 11.1. X-ray fluorescence values for Border Star 85 obsidian samples

Element	OCA Sample Number															
	052–06	009–28	170–03	073–10	251–22	017–1.02	076–07	017–2.01	009–005	186–08	082–06	009–30	145–04	208–06	189–01	128–06
Na	10	15	15	30	10	13	10	15	10	15	18	10	12	14	10	15
Mg	20	20	20	30	10	21	15	10	40	15	20	15	23	20	15	18
Al	71	20	24	70	40	25	30	40	80	70	60	70	40	42	20	60
Si	680	580	590	600	506	210	440	310	650	620	590	660	405	440	150	520
S	0	0	0	0	0	0	0	0	80	60	0	110	90	120	0	110
P	90	130	100	120	60	30	50	50	80	60	90	90	40	50	0	70
Cl	120	70	60	0	140	30	0	52	0	0	0	0	0	0	0	0
K	1160	1070	1140	1400	1110	340	870	830	1450	1100	1250	1400	1233	910	290	1311
Ca	1110	460	400	420	310	110	310	240	310	270	340	210	260	290	70	200
Sc	210	0	70	0	0	0	80	50	0	0	0	0	0	0	0	0
Ti	130	130	170	170	140	56	81	80	170	110	130	140	150	130	80	180
Mn	390	350	340	360	300	73	210	200	350	410	580	290	190	220	80	340
Fe	4730	4320	4380	5452	4440	730	2766	1901	4800	3080	3340	4290	2530	2080	770	4492
Cu	500	360	400	460	330	110	370	260	800	480	400	460	390	340	130	440
Zn	530	510	460	540	520	120	260	240	430	310	490	500	250	200	80	445
Pb	420	0	0	370	0	0	240	0	0	0	0	300	0	0	110	0
Rb	470	450	430	450	370	100	140	270	490	500	780	370	0	250	100	470
Zr	670	400	480	460	430	80	190	0	460	0	700	0	240	0	0	370
Nb	460	0	0	520	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	90	120	110	90	60	60	60	110	0	90	140	0	0	0	100
Co	0	450	0	0	380	90	0	0	1010	720	0	0	0	0	0	0
Mo	0	0	0	0	0	0	0	0	380	0	0	0	0	0	0	0
Ni	0	360	230	360	0	110	170	190	0	220	0	0	150	0	0	240
Se	0	360	440	490	0	100	280	170	480	0	550	480	400	310	100	520
Ge	0	0	830	0	700	0	0	0	0	0	0	810	0	0	140	850
Ga	0	0	0	500	0	0	0	210	0	0	580	0	0	410	0	0
Sr	0	0	0	0	250	0	0	0	0	0	330	0	0	0	120	0

Table 11.1. (continued)

Element	OCA Sample Number															
	009–19	017–19.01	009–11	017–16	231–02	009–07	017–2.03	017–19.6	067–02	101–11	009–27	182–63	083–05	185–31	185–29	101–01
Na	10	15	10	12	21	14	10	29	22	10	12	11	21	14	13	11
Mg	20	22	21	23	16	21	15	34	40	14	18	15	25	24	19	30
Al	40	60	61	31	81	62	21	63	81	35	35	100	100	70	50	51
Si	520	551	300	603	620	670	273	701	680	370	250	480	600	510	580	400
S	360	80	50	100	130	140	20	133	111	70	0	60	180	90	130	90
P	80	160	20	90	60	70	40	130	80	40	20	70	160	70	90	60
Cl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K	420	1072	590	1460	1191	1440	550	1433	1492	650	550	1280	1400	1333	1335	1032
Ca	200	290	150	340	333	280	190	351	350	190	100	230	310	230	210	190
Sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ti	80	90	60	200	140	130	60	190	190	90	50	140	150	140	130	100
Mn	130	500	150	340	341	370	160	250	430	210	120	320	350	360	400	390
Fe	1682	3280	2020	5160	4711	4660	1677	5000	5460	2330	1672	3820	4876	3964	4320	2590
Cu	110	370	160	380	490	460	210	480	610	320	270	410	620	430	640	400
Zn	0	410	220	470	370	490	230	500	490	200	140	380	480	320	420	370
Pb	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0
Rb	430	630	180	400	390	380	160	480	530	150	0	400	580	420	460	550
Zr	360	0	0	440	490	570	0	500	550	100	0	350	560	0	0	330
Nb	0	470	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0	0	0	0	0	100	60	0	0	0	60	100	130	0	0	0
Co	0	0	0	0	0	0	0	1051	1090	0	0	790	0	0	0	0
Mo	0	0	0	0	0	0	0	0	0	0	0	0	590	450	0	0
Ni	130	0	0	0	0	340	0	290	370	0	0	0	340	270	0	0
Se	0	440	240	510	510	510	0	660	630	190	190	380	390	390	0	340
Ge	0	0	420	0	760	0	320	740	940	0	260	660	0	700	550	610
Ga	210	0	0	510	0	410	0	520	690	310	0	0	0	540	0	530
Sr	170	0	180	0	0	0	0	0	0	130	0	0	0	0	0	0

Table 11.1. (continued)

Element	OCA Sample Number															
	009–08	017–19.02	017–2.02	062–09	017–19.04	063–08	187–03	041–02	064–04	017–19.05	119–02	017–2.06	031–02	009–06	072–03	185–16
Na	14	16	12	14	12	15	13	21	11	12	15	10	15	30	20	12
Mg	21	24	32	21	21	19	18	23	22	15	22	20	25	24	18	18
Al	70	110	60	62	40	50	80	62	75	82	60	28	50	80	110	50
Si	690	760	640	610	600	605	500	660	580	620	810	70	660	690	855	715
S	130	190	120	122	0	80	70	100	92	0	130	30	110	0	150	102
P	80	140	70	140	60	0	60	120	90	110	140	20	80	100	90	52
Cl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K	1390	1800	1076	1355	1152	1035	1034	1533	1300	1622	1675	160	1274	1555	1824	1244
Ca	350	280	280	240	160	150	170	440	310	390	430	30	280	350	400	305
Sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ti	100	150	110	200	120	90	120	111	110	220	140	20	180	250	240	110
Mn	540	400	350	450	340	260	320	580	400	390	510	42	310	380	470	250
Fe	3330	6054	3711	5234	4110	4254	3835	3910	4142	4780	5110	240	4715	5740	5834	4393
Cu	630	770	600	570	670	460	490	410	370	500	600	80	470	560	720	460
Zn	390	480	320	400	310	400	380	538	500	450	520	60	420	520	460	450
Pb	0	480	290	0	0	0	0	360	0	0	440	30	0	0	390	0
Rb	610	610	530	570	370	300	290	730	380	400	920	40	360	610	640	320
Zr	440	615	0	560	380	270	0	490	440	480	0	20	0	690	720	390
Nb	0	0	0	0	0	0	0	0	0	0	930	0	370	550	0	0
Cr	110	0	0	100	0	0	0	0	0	150	0	0	140	0	170	0
Co	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo	0	0	0	470	0	300	0	492	0	500	630	0	0	0	0	0
Ni	260	0	310	0	0	0	180	260	0	390	360	0	370	330	0	0
Se	440	570	350	460	410	330	240	0	410	0	720	0	490	600	540	460
Ge	700	0	810	930	640	540	640	890	830	860	1090	80	0	0	0	0
Ga	0	0	560	565	360	510	530	0	502	0	0	0	390	530	0	300
Sr	0	470	340	0	0	0	0	400	0	0	0	20	0	0	0	0

compares the position of the unknown sample to the centroid of each source group to determine the source most similar to the unknown sample.

While many elements may be identified in a given sample, it is probable that only a subset of these are strong discriminators of group membership. A forward stepwise discriminant procedure (STEPDISC in SAS) was used to identify weak or redundant elements of this analysis. In doing so, the best (strongest) discriminators are used automatically in the classification procedure. Forward selection also ignores unique elements in a few specimens because these elements do not contribute significantly to the overall classification equations.

Forward stepwise discriminant analysis chooses a variable for inclusion in the classification model on the basis of the power of that variable to separate samples into groups. The power to discriminate (or separate) is measured by Wilks' lambda, the likelihood ratio criterion. The forward stepwise procedure ends when none of the previously unselected variables meets the entry criterion.

Results and Discussion

In the first step of the discriminant function analysis, the 12 known sources shown in Table 11.2 were analyzed. In this analysis, data from all known samples were used to separate obsidian source areas. This step resulted in 96 percent of the samples being classified correctly (compare the first two columns in Table 11.2). The only misclassifications that occurred while developing the discriminant function were between samples collected from secondary deposits—the Pleistocene terraces along the Rio Grande. Even though these samples were collected from a 200 mi stretch of the Rio Grande drainage (from near Cochiti, Los Lunas, and Las Cruces), they show a moderate amount of geochemical and statistical similarity. These misclassifications do not detract from the statistical results; rather, they suggest that these sources, which have similar depositional histories, may be genetically related. In fact, samples from sources that have been distinguished by neutron activation analysis (NAA) were also shown to be distinctive by these XRF and discriminant function analyses (cf. Galm 1975 and samples NAC1-3 in Table 11.2).

After the function or "calibration value" was developed, which distinguishes between these sources, it was applied to the unknown (archeological) samples submitted by OCA (Table 11.3). When the unknown samples were compared to those from the 13 known sources, the former were classified predominantly as local—that is, from the Tularosa Basin source(s). The only samples not classified as local in origin are 017-1.20, 076-07, 017-2.01, 009-11, 017-2.03, 186-08, 145-04, 208-06, 189-01, 101-11, 009-27, 063-08, 187-03, and 017-2.06. Thirteen of these samples were classified as coming from the Las Cruces area, while one (Sample 009-11) was traced to the Cochiti Pleistocene gravels. As previously discussed, the Rio Grande gravel sources are geochemically similar, and it is difficult to discriminate among them. This difficulty is further evidenced by the posterior probability of membership coefficients (Table 11.3). In the case of Sample 009-11, the difference in the probability of the sample being from either the Las Cruces or Cochiti area is minimal and possibly results from source sample error. Consequently, we infer that all the samples submitted by OCA were derived prehistorically either from immediately local sources in the Tularosa Basin or from the nearby Mesilla Valley.

A stepwise discriminant analysis was performed to isolate the most sensitive elements that distinguish the known

Table 11.2. Classification results of known sources using all elements

Known Group	Classified Group	RG1	SA	NAC1	GR	NAC2	NAC3	J	RG3	RG2	MC	TB	PP	RH
TB	TB	0	0	0	0	0	0	0	0	0	0	1	0	0
TB	TB	0	0	0	0	0	0	0	0	0	0	1	0	0
TB	TB	0	0	0	0	0	0	0	0	0	0	1	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
NAC1	NAC1	0	0	1	0	0	0	0	0	0	0	0	0	0
MC	MC	0	0	0	0	0	0	0	0	0	1	0	0	0
MC	MC	0	0	0	0	0	0	0.0003	0	0	0.9997	0	0	0
MC	MC	0	0	0	0	0	0.0072	0	0	0	0.9928	0	0	0
MC	MC	0	0	0	0	0	0	0	0	0	1	0	0	0
MC	MC	0	0	0	0	0	0	0	0	0	1	0	0	0
MC	MC	0	0	0	0	0	0	0	0	0	1	0	0	0
MC	MC	0	0	0	0	0	0	0	0	0	1	0	0	0
MC	MC	0	0	0	0	0.0001	0	0	0	0	0.9999	0	0	0
MC	MC	0	0	0	0	0	0	0	0	0	1	0	0	0
MC	MC	0	0	0	0	0	0	0	0	0	1	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0.0144	0	0	0	0	0	0.9849	0.0007	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
J	J	0	0	0	0	0	0	1	0	0	0	0	0	0
RH	RH	0	0	0	0	0	0	0	0	0	0	0	0	1
RH	RH	0	0	0	0	0	0	0	0	0	0	0	0	1
RH	RH	0	0	0	0	0	0	0	0	0	0	0	0	1
RH	RH	0	0	0	0.0001	0	0	0	0	0	0	0	0	0.9999
RH	RH	0	0	0	0	0	0	0	0	0	0	0	0	1
RH	RH	0	0	0	0	0	0	0	0	0	0	0	0	1
RH	RH	0	0	0	0	0	0	0	0	0	0	0	0	1
RH	RH	0	0	0	0	0	0	0	0	0	0	0	0	1
RH	RH	0	0	0	0	0	0	0	0	0	0	0	0	1
RH	RH	0	0	0	0	0	0	0	0	0	0	0	0	1
NAC3	NAC3	0	0	0	0	0	1	0	0	0	0	0	0	0
NAC3	NAC3	0	0	0	0	0	1	0	0	0	0	0	0	0
NAC3	NAC3	0	0	0	0	0	1	0	0	0	0	0	0	0
NAC3	NAC3	0	0	0	0	0	1	0	0	0	0	0	0	0
NAC3	NAC3	0	0	0	0	0	1	0	0	0	0	0	0	0
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0

Table 11.2. (continued)

Known Group	Classified Group	RG1	SA	NAC1	GR	NAC2	NAC3	J	RG3	RG2	MC	TB	PP	RH
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0
SA	SA	0	1	0	0	0	0	0	0	0	0	0	0	0
NAC2	NAC2	0	0	0	0	1	0	0	0	0	0	0	0	0
NAC2	NAC2	0	0	0	0	0.9990	0.0010	0	0	0	0	0	0	0
NAC2	NAC2	0	0	0	0	1	0	0	0	0	0	0	0	0
NAC2	NAC2	0	0	0	0	1	0	0	0	0	0	0	0	0
NAC2	NAC2	0	0	0	0	1	0	0	0	0	0	0	0	0
GR	GR	0	0	0	1	0	0	0	0	0	0	0	0	0
GR	GR	0	0	0	1	0	0	0	0	0	0	0	0	0
GR	GR	0	0	0	1	0	0	0	0	0	0	0	0	0
GR	GR	0	0	0	1	0	0	0	0	0	0	0	0	0
GR	GR	0	0	0	1	0	0	0	0	0	0	0	0	0
GR	GR	0	0	0	1	0	0	0	0	0	0	0	0	0
GR	GR	0	0	0	1	0	0	0	0	0	0	0	0	0
GR	GR	0	0	0	1	0	0	0	0	0	0	0	0	0
GR	GR	0	0	0	0.9998	0	0	0	0	0	0	0	0	0.0002
GR	GR	0	0	0	1	0	0	0	0	0	0	0	0	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
PP	PP	0	0	0	0	0	0	0	0	0	0	0	1	0
RG1	RG1	0.9953	0	0	0	0	0	0	0.0047	0	0	0	0	0
RG1	RG1	0.9104	0	0	0	0	0	0	0.0896	0	0	0	0	0
RG1	RG1	0.7477	0	0	0	0	0	0	0.2523	0	0	0	0	0
RG1	RG1	0.8903	0	0	0	0	0	0	0.1097	0	0	0	0	0
RG1	RG1	0.5869	0	0	0	0	0	0	0.4131	0	0	0	0	0
RG1	RG1	0.8931	0	0	0	0	0	0	0.1069	0	0	0	0	0
RG1	RG1	0.7948	0	0	0	0	0	0	0.2052	0	0	0	0	0
RG1	RG1	0.4539	0	0	0	0	0	0	0.5461	0	0	0	0	0
RG1	RG1	0.8049	0	0	0	0	0	0	0.1951	0	0	0	0	0
RG1	RG1	0.9862	0	0	0	0	0	0	0.0138	0	0	0	0	0
RG3	RG3	0.0259	0	0	0	0	0	0	0.9741	0	0	0	0	0
RG3	RG3	0.0216	0	0	0	0	0	0	0.9784	0	0	0	0	0
RG3	RG3	0	0	0	0	0	0	0	0	1	0	0	0	0
RG3	RG3	0.6227	0	0	0	0	0	0	0.3773	0	0	0	0	0
RG3	RG3	0.4774	0	0	0	0	0	0	0.5226	0	0	0	0	0
RG3	RG3	0.2901	0	0	0	0	0	0	0.7099	0	0	0	0	0
RG3	RG3	0.0021	0	0	0	0	0	0	0.9968	0.0011	0	0	0	0
RG3	RG3	0.8558	0	0	0	0	0	0	0.1442	0	0	0	0	0
RG3	RG3	0.6486	0	0	0	0	0	0	0.3514	0	0	0	0	0
RG3	RG3	0.1988	0	0	0	0	0	0	0.8012	0	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0	1	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0	1	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0	1	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0.0014	0.9986	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0	1	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0	1	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0	1	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0	1	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0	1	0	0	0	0
RG2	RG2	0	0	0	0	0	0	0	0	1	0	0	0	0

Key:

GR	Grants Ridge (3510)[a]
J	Jemez (3520, 3521, 3522, 3523, 3524, 3525, 3526)[b]
MC	Mule Creek (3540)[a]
NAC1	Neutron activation comparative samples, Burns Oregon
NAC2	Neutron activation comparative samples, Glass Buttes, Oregon
NAC3	Neutron activation comparative samples, Glass Buttes, Oregon
PP	Polvadero Peak (3530)[a]
RG1	Rio Grande Pleistocene terrace gravels, Cochiti vicinity
RG2	Rio Grande Pleistocene terrace gravels, Las Lunas vicinity
RG3	Rio Grande Pleistocene terrace gravels, Las Cruces vicinity
RH	Red Hill (3550)[b]
SA	San Antonio Mountain
TB	Tularosa Basin

Numbers in parentheses are lithic source numbers used by Warren: [a]Warren (1977:26–27)
[b]Warren (1979:31)

Table 11.3. Classification of archaeological samples using all variables

Sample No.	Classified Source	RG1	NAC1	GR	NAC2	NAC3	J	RG3	RG2	MC	TB	PP	RH	SA
052-06	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-28	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
170-03	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
073-10	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
251-22	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-1.02	RG3	0.2673	0	0	0	0	0	0.7327	0	0	0	0	0	0
076-07	RG3	0.2150	0	0	0	0	0	0.7850	0	0	0	0	0	0
017-2.01	RG3	0.0379	0	0	0	0	0	0.9621	0	0	0	0	0	0
009-19	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-19.01	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-11	RG1	0.5271	0	0	0	0	0	0.4729	0	0	0	0	0	0
231-02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-07	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-2.03	RG3	0.1740	0	0	0	0	0	0.8260	0	0	0	0	0	0
017-19.6	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-005	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
186-08	RG3	0.0253	0	0	0	0	0	0.9747	0	0	0	0	0	0
082-06	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-30	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
145-04	RG3	0.4491	0	0	0	0	0	0.5509	0	0	0	0	0	0
208-06	RG3	0.0180	0	0	0	0	0	0.9820	0	0	0	0	0	0
189-01	RG3	0.1466	0	0	0	0	0	0.8532	0.0002	0	0	0	0	0
128-06	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
067-02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
101-11	RG3	0.0532	0	0	0	0	0	0.9468	0	0	0	0	0	0
009-27	RG3	0.1061	0	0	0	0	0	0.8939	0	0	0	0	0	0
182-63	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
185-31	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
185-29	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
101-01	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-08	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-19.02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-2.02	TB	0.0001	0	0	0	0	0	0.0115	0	0	0.9884	0	0	0
062-09	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-19.04	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
063-08	RG3	0.0175	0	0	0	0	0	0.9825	0	0	0	0	0	0
187-03	RG3	0.0592	0	0	0	0	0	0.9408	0	0	0	0	0	0
041-02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
064-04	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-19.05	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-2.06	RG3	0.2135	0	0	0	0	0	0.7865	0	0	0	0	0	0
031-02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-06	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
072-03	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
185-16	TB	0.0070	0	0	0	0	0	0.0300	0	0	0.9631	0	0	0

For key to abbreviations in headings see .ey in Table 11.2.

sources by XRF data. Unlike the first analysis, which considered all variables, this analysis selected variables for inclusion based upon both their individual and collective abilities to discriminate between known groups of material. This analysis selected 22 variables from the original 45 as the best discriminators. When applied to the known obsidian source XRF data, the discriminant function with the reduced number of variables resulted in a 92 percent correct solution. The discriminant function with 22 variables separated the archeological samples in an almost identical manner to the solution that employed the original group of 45 variables (Table 11.4). If more samples were to be included in future analyses, this reduced set of variables could be used. Those variables selected by the stepwise discriminant analysis, in order of their appearance in the discriminant function equation, are P, Fe, Mn, K, Mo, Nb, Ti, Rb, Cu, Bi, Ca, Pb, Mg, Br, Ba, Zn, Fr, Sr, Ge, Se, Si, and Ac. It should not be inferred that this ordering of individual elements indicates that P is strongest discriminator, followed by Fe, then Mn, etc.

Implications for Obsidian Hydration Dating

The geochemical similarity in the samples submitted by OCA suggests that variation in hydration rates among these obsidian samples should be a function primarily of time and depositional environment. If the depositional history could be determined for groups of geochemically similar subsamples, and an empirical, independent chronology could be established for some of these samples, then the rate of hydration could be applied to other samples from undated contexts and chronometric dates assigned to the

Table 11.4. Classification of archaeological samples using reduced set of variables

Sample No.	Classified Source	RG1	NAC1	GR	NAC2	NAC3	J	RG3	RG2	MC	TB	PP	RH	SA
052-06	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-28	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
170-03	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
073-10	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
251-22	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-1.02	RG1	0.6327	0	0	0	0	0	0.3423	0.0250	0	0	0	0	0
076-07	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-2.01	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-19	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-19.01	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-11	RG1	0.6828	0	0	0	0	0	0.3170	0.0002	0	0	0	0	0
231-02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-07	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-2.03	RG1	0.6015	0	0	0	0	0	0.3148	0.0836	0	0	0	0	0
017-19.6	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-005	RG3	0.1491	0	0	0	0	0	0.8509	0	0	0	0	0	0
186-08	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
082-06	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-30	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
145-04	RG1	0.5505	0	0	0	0	0	0.4494	0.0001	0	0	0	0	0
208-06	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
189-01	RG3	0.1806	0	0	0	0	0	0.8192	0.0002	0	0	0	0	0
128-06	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
067-02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
101-11	RG1	0.5030	0	0	0	0	0	0.4639	0.0331	0	0	0	0	0
009-27	RG3	0.3233	0	0	0	0	0	0.6765	0.0002	0	0	0	0	0
182-63	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
185-31	RG1	0.9706	0	0	0	0	0	0.0294	0	0	0	0	0	0
1[illegible]5-29	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
101-01	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-08	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-19.02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-2.02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
062-09	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-19.04	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
063-08	RG3	0.0345	0	0	0	0	0	0.9655	0	0	0	0	0	0
187-03	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
041-02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
064-04	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-19.05	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
017-2.06	RG3	0.4452	0	0	0	0	0	0.5437	0.0111	0	0	0	0	0
031-02	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
009-06	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
072-03	TB	0	0	0	0	0	0	0	0	0	1	0	0	0
185-16	TB	0	0	0	0	0	0	0	0	0	1	0	0	0

For key to abbreviations in headings see key in Table 11.2.

otherwise undated contexts. Alternatively, samples of unweathered obsidian from these sources could be weathered artificially (i.e., induced hydration). If induced hydration is the only possible alternative, one must accept the assumption that the hydration process is linear. This assumption may be valid in some instances but not in others (Meighan 1976). Unfortunately, there is no a priori method for assessing the validity of such an assumption.

Both the temperature and the chemical characteristics of the depositional environment affect the hydration behavior of obsidian. Mean annual soil temperature (MAST), pH, Eh, total matrix organic content, local groundwater and soil moisture geochemistry, and atmospheric moisture all affect the hydration process. If hydration is induced, then the researcher must duplicate the natural environmental conditions as accurately as possible. Noncomparable results are obtained when many of the environmental variables are not replicated accurately during induced hydration experiments.

Because of the possible nonlinear progression of the hydration process (Meighan 1976), methods and techniques used to replicate and interpret the hydration process probably will not be as simple as those described by some (e.g., Batcho 1984). Nonlinear regression techniques may be required to fit the experimental data to a line. To address this question, induced obsidian hydration results need to be compared with a curve generated through cross correlation. Such a procedure should indicate weaknesses or inaccuracies in the induced regional obsidian hydration rates.

Conclusions

Rapid XRF analysis of the obsidian samples recovered by the University of New Mexico's Office of Contract Archeology during the Border Star 85 project indicates that a majority of these samples were probably acquired prehistorically either from the immediate vicinity of the Tularosa Basin or from the Pleistocene terrace gravels in the nearby Mesilla Valley.

Interpretation of the geochemical homogeneity of these samples suggests that differential hydration of these samples is probably a function of variation in the depositional environment and the time that has elapsed since their last modification. Consequently, if the depositional history can be determined for this sample set, and a method can be developed for establishing a hydration rate for the two sources, then obsidian samples from otherwise undatable sites can be assigned to a more or less absolute temporal framework.

Alternatively, hydration rim thickness can be measured, and the samples can then be placed on a relative scale; that is, wider rims will imply older dates than thinner rims on geochemically similar materials. These data could be used to infer single vs multicomponent cultural sites.

XRF Analysis of Phase II Samples

The Phase II obsidian artifacts were subsampled for x-ray fluorescence (XRF) analysis in the same manner as the samples from the first phase. During the subsampling procedure, 16 samples were found to be too small for both XRF analysis and hydration studies. After discussions with OCA personnel, it was decided that these artifacts would not be sawed and would be used only for XRF analysis. These samples are 503-37, 503-79, 503-64, 502-9, 503-90, 503-91, 504-24, 502-23, 503-138, 502-21, 502-37, 502-26, 502-39, 502-17, and 502-19. All samples were prepared and analyzed using the techniques employed in Phase I XRF analysis (see above).

Data generated by XRF analysis were compared to the values from the same known sources used in Phase I comparisons. An attempt was made, however, to refine the XRF spectrum of the Tularosa Basin source, identified through Phase I work, by adding additional "natural nodule" ("Apache Tear") sample values to better define source area geochemical parameters.

Initial results of the multivariate discriminant function analysis using the expanded data base were unsatisfactory. Previously characterized source area samples from outside the study area were input as controls in the analysis. These samples were misclassified, and consequently the results were rejected.

To minimize any variations possibly introduced through attrition in XRF detecting apparatus, or variation in absolute sample size, all XRF values for both known and unknown samples were converted to ratios. Ratios of all other elements to iron (Fe) were calculated within samples, and these data were then analyzed with the discriminant function programs. This manipulation still resulted in misclassifications of known samples. In an effort to understand the misclassifications, further examinations were made of the additional "Apache Tear" samples added in Phase II analysis. Their XRF values and microscopic and macroscopic characteristics were carefully evaluated.

Three of the five source area samples submitted by OCA during Phase II display XRF values that are interpreted as possibly representing basaltic glass (tachylyte) rather than rhyolitic glass (obsidian). These samples have XRF values that are comparatively lower in silica, aluminum, iron, and potassium. Magnesium values, which should be higher in basaltic glass than in obsidian, are more difficult to interpret. Microscopic and macroscopic examination of remaining subsamples indicated decreased translucency, a characteristic associated with basaltic glass (tachylyte). Consequently, XRF data discussed here are the result of comparing unknown samples from Phase II investigations and projectile points recovered from Phase I and II with the XRF spectrums, converted to ratios, used in Phase I. This analysis resulted in current classification of non-study area samples and mimicked previous classification of Phase I samples. At the same time these analyses identified obsidians from nonlocal sources. Statistical analysis using the rhyolitic Phase II samples in characterization of the Tularosa Basin source and classification of the unknown (archeological) samples are still ongoing.

Discriminant Function Analysis

A stepwise discriminant function analysis, using both forward and backward selection routines, was run to identify the best discriminating variables. These procedures resulted in the selection of ratio values for 16 elements: Si, K, Ti, Mn, Lu, Pb, Cu, Ge, Se, Rb, Sr, Ba, Zn, Ac, Ga, and Bi. This is six fewer elements than were used in Phase I statistical analysis and constitutes a slightly different suite of elements. This suite includes Lu and Ga, which were not included in Phase I, and excludes Mo, Nb, Ca, Br, Fr, and P, which were used in Phase I.

Classification of known sources by discriminant function analysis results in a 91.3 percent correct solution (Table 11.5). The nine misclassified cases include samples from the Rio Grande Pleistocene terrace gravel sources and some from the Jemez Mountains. This is a very similar solution to the results of the Phase I analysis (Table 11.2). The most substantial difference between this analysis and that of Phase I is the misclassification of the Jemez Mountains samples. This misclassification may support the contention that at least some of the Rio Grande gravels were originally derived from the Jemez area (Michels 1984a, 1984b, 1984c, 1984d, 1984e).

Sources, Associations, and Assumptions

Results of XRF and discriminant function analyses are interpreted as indicating that all obsidian samples recovered during the Border Star project were derived from four sources: the Tularosa Basin, Rio Grande Pleistocene terrace gravel, Red Hill, and Polvadera Peak sources.

The Tularosa Basin material is represented by debitage

Table 11.5. Classification results of known sources using 16 selected elements

Known Group	Classified Group	RG1	GR	J	RG3	RG2	MC	TB	PP	RH	SA
TB	TB	0	0	0	0	0	0	1	0	0	0
TB	TB	0	0	0	0	0	0	1	0	0	0
TB	TB	0	0	0	0	0	0	1	0	0	0
MC	MC	0	0	0.0015	0	0	0.9985	0	0	0	0
MC	MC	0.0003	0	0.0053	0.0002	0	0.9941	0	0	0	0
MC	MC	0	0	0	0	0	1	0	0	0	0
MC	MC	0.0004	0	0.0017	0.0001	0	0.9979	0	0	0	0
MC	MC	0.0001	0	0.0001	0	0	0.9998	0	0	0	0
MC	MC	0	0	0	0	0	1	0	0	0	0
MC	MC	0	0	0	0	0	1	0	0	0	0
MC	MC	0	0	0	0	0	1	0	0	0	0
MC	MC	0.0001	0	0	0	0	0.9999	0	0	0	0
MC	MC	0	0	0	0	0	1	0	0	0	0
J	J	0.0801	0	0.9043	0.0131	0	0.0025	0	0	0	0
J	J	0.0349	0	0.9425	0.0226	0	0	0	0	0	0
J	J	0.0198	0	0.9750	0.0051	0	0	0	0	0	0
J	J	0.0008	0	0.9991	0.0002	0	0	0	0	0	0
J	J	0.0052	0	0.9944	0.0004	0	0	0	0	0	0
J	J	0.0729	0	0.9229	0.0042	0	0	0	0	0	0
J	J	0.0317	0	0.9668	0.0015	0	0	0	0	0	0
J	J	0.0483	0	0.9512	0.0005	0	0	0	0	0	0
J	RG3	0.1061	0	0.3092	0.5843	0	0.0004	0	0	0	0
J	J	0.1880	0	0.6812	0.1304	0	0.0003	0	0	0	0
J	J	0.0718	0	0.9133	0.0148	0	0.0001	0	0	0	0
J	J	0.0061	0	0.9847	0.0092	0	0	0	0	0	0
J	RG3	0.4203	0	0.1047	0.4750	0	0	0	0	0	0
J	J	0.0269	0	0.9683	0.0048	0	0	0	0	0	0
J	RG1	0.8541	0	0.0329	0.1130	0	0	0	0	0	0
J	J	0.0111	0	0.9846	0.0043	0	0	0	0	0	0
J	J	0.0979	0	0.8558	0.0463	0	0	0	0	0	0
J	J	0.0097	0	0.9809	0.0094	0	0	0	0	0	0
J	J	0.1519	0	0.7140	0.1341	0	0	0	0	0	0
J	J	0.0161	0	0.9795	0.0044	0	0	0	0	0	0
RH	RH	0	0	0	0	0	0	0	0	1	0
RH	RH	0	0	0	0	0	0	0	0	1	0
RH	RH	0	0	0	0	0	0	0	0	1	0
RH	RH	0	0	0	0	0	0	0	0	1	0
RH	RH	0	0	0	0	0	0	0	0	1	0
RH	RH	0	0	0	0	0	0	0	0	1	0
RH	RH	0	0	0	0	0	0	0	0	1	0
RH	RH	0	0	0	0	0	0	0	0	1	0
RH	RH	0	0	0	0	0	0	0	0	1	0
RH	RH	0	0	0	0	0.0008	0	0	0	0.9992	0
SA	SA	0	0	0	0	0	0	0	0	0	1
SA	SA	0	0	0	0	0	0	0	0	0	1
SA	SA	0	0	0	0	0	0	0	0	0	1
SA	SA	0	0	0	0	0	0	0	0	0	1
SA	SA	0	0	0	0	0	0	0	0	0	1
SA	SA	0	0	0	0	0	0	0	0	0	1
SA	SA	0	0	0	0	0	0	0	0	0	1
SA	SA	0	0	0	0	0	0	0	0	0	1
SA	SA	0	0	0	0	0	0	0	0	0	1
SA	SA	0	0	0	0	0	0	0	0	0	1
GR	GR	0	0.9045	0	0	0.0955	0	0	0	0	0
GR	GR	0	0.9990	0	0	0.0010	0	0	0	0	0
GR	GR	0	0.5794	0	0	0.4206	0	0	0	0	0
GR	GR	0	0.5910	0	0	0.4090	0	0	0	0	0
GR	GR	0	0.9999	0	0	0.0001	0	0	0	0	0
GR	GR	0	0.9998	0	0	0.0002	0	0	0	0	0
GR	GR	0	1	0	0	0	0	0	0	0	0
GR	GR	0	0.9991	0	0	0.0009	0	0	0	0	0
GR	GR	0	0.9983	0	0	0	0	0	0	0.0017	0
GR	GR	0	1	0	0	0	0	0	0	0	0
PP	PP	0	0	0	0	0	0	0	1	0	0
PP	PP	0	0	0	0	0	0	0	1	0	0
PP	PP	0	0	0	0	0	0	0	1	0	0
PP	PP	0	0	0	0	0	0	0	1	0	0
PP	PP	0	0	0	0	0	0	0	1	0	0
PP	PP	0	0	0	0	0	0	0	1	0	0
PP	PP	0	0	0	0	0	0	0	1	0	0
PP	PP	0	0	0	0	0	0	0	1	0	0

Table 11.5. (continued)

Known Group	Classified Group	RG1	GR	J	RG3	RG2	MC	TB	PP	RH	SA
PP	PP	0	0	0	0	0	0	0	1	0	0
PP	PP	0	0	0	0	0	0	0	1	0	0
RG1	RG1	0.9741	0	0.0001	0.0258	0	0	0	0	0	0
RG1	RG1	0.5521	0	0.0543	0.3936	0	0	0	0	0	0
RG1	J	0.2255	0	0.7545	0.0199	0	0	0	0	0	0
RG1	RG1	0.7567	0	0.2146	0.0286	0	0.0001	0	0	0	0
RG1	RG1	0.5924	0	0.0665	0.3407	0	0.0004	0	0	0	0
RG1	RG1	0.7290	0	0.0363	0.2345	0	0.0002	0	0	0	0
RG1	RG1	0.5921	0	0.1097	0.2979	0	0.0002	0	0	0	0
RG1	RG3	0.2891	0	0.0126	0.6983	0	0	0	0	0	0
RG1	RG1	0.5668	0	0.0196	0.4137	0	0	0	0	0	0
RG1	RG1	0.8745	0	0.0465	0.0790	0	0	0	0	0	0
RG3	RG3	0.2927	0	0.0094	0.6980	0	0	0	0	0	0
RG3	RG3	0.2321	0	0.0006	0.7673	0	0	0	0	0	0
RG3	RG2	0	0.0011	0	0	0.9989	0	0	0	0	0
RG3	RG3	0.4307	0	0.0993	0.4700	0	0	0	0	0	0
RG3	RG1	0.4960	0	0.0789	0.4251	0	0	0	0	0	0
RG3	RG3	0.1530	0	0.0106	0.8314	0	0	0	0	0	0
RG3	RG3	0.0054	0	0.0033	0.9864	0.0043	0.0006	0	0	0	0
RG3	J	0.1145	0	0.8383	0.0472	0	0	0	0	0	0
RG3	RG3	0.4741	0	0.0210	0.5049	0	0	0	0	0	0
RG3	RG1	0.8553	0	0.0106	0.1340	0	0	0	0	0	0
RG3	RG2	0	0	0	0	1	0	0	0	0	0
RG3	RG2	0	0.0003	0	0	0.9997	0	0	0	0	0
RG3	RG2	0	0.0004	0	0	0.9996	0	0	0	0	0
RG3	RG2	0.0004	0.0006	0.0001	0.0740	0.9249	0	0	0	0	0
RG3	RG2	0	0.0023	0	0	0.9977	0	0	0	0	0
RG3	RG2	0	0.0002	0	0	0.9998	0	0	0	0	0
RG3	RG2	0	0.0002	0	0	0.9998	0	0	0	0	0
RG3	RG2	0	0.0180	0	0	0.9820	0	0	0	0	0
RG3	RG2	0	0.0007	0	0	0.9993	0	0	0	0	0
RG3	RG2	0	0.0317	0	0	0.9683	0	0	0	0	0

For key to abbreviations in headings see key in Table 11.2.

and typed bifaces. All sites with obsidian, except 121–6, 1383, 2654, 2254, and 1091, provided samples of Tularosa Basin obsidian (Table 11.6).

Obsidian samples from Rio Grande Pleistocene terrace gravels are also present as debitage and typed bifaces (Table 11.7). As pointed out in the Phase I analysis, known samples from various locations along the Rio Grande (Las Cruces, Los Lunas, and Cochiti) are very heterogeneous and difficult to separate from each other; however, these secondary sources are statistically distinct from other primary sources, except for a subsample from the Jemez Mountains. These results are somewhat at odds with those of Michels (1984a, 1984b, 1984c, 1984d, 1984e), who has identified a number of distinct Rio Grande terrace gravel groups. Our results do lend support to Michels' contention that some of the Rio Grande gravels were derived from a flow, or flows, in the Jemez area. We believe that the differences between our results and those of Michels stem from the number of samples and concomitant wide range of variation represented by our more intense source area sampling strategy.

Other more distant sources indicated by these analyses are Red Hill and Jemez. Obsidian samples from the Red Hill source were recovered from three sites (Table 11.7). This material is present as debitage and typed bifaces. Only one sample, a San Pedro style biface, was characterized as coming from the Polvadera Peak source in the Jemez Mountains (Table 11.7).

In general, it appears that early (Archaic) and late (El Paso, Mesilla/El Paso) phase sites show more variation in obsidian sources than do middle (Mesilla/Late Mesilla) phase sites.

Obsidian Hydration Analysis

All samples submitted by OCA to OHL were subsampled for obsidian hydration rim measurement, except those samples noted above as being too small for both XRF and hydration studies. No attempt was made to derive calendric ages for hydration readings. Calculations of calendric dates can be accomplished through correlation with associated dates or through induced hydration measurements of geochemically similar obsidians. Because of the nature of the samples (surface collection) and the contract with OCA (which called for rim measurement only), no obsidian dates are presented here; however, some general trends within geochemically similar obsidians are discernible.

Table 11.6. Results of hydration analysis of Tularosa Basin XRF group

Site Number	Catalog Number	Associated Date(s)	Degree of Sandblasting	Depth	s
1896	502-37	Early Archaic	—	XRF Only	—
1896	502-39	Early Archaic	—	XRF Only	—
1896	502-23	Early Archaic	—	XRF Only	—
1896	502-26	Early Archaic	—	XRF Only	—
1896	502-21	Early Archaic	—	XRF Only	—
1124	503-79	Paleo, Post Archaic	—	XRF Only	—
1124	503-64	Paleo, Post Archaic	—	XRF Only	—
1388	101-11	Early Mesilla(?)	L	5.2	0.69
1231	72-3	Early Mesilla(?)	M	3.8	0.37
1667	82-6	Early Mesilla	H	2.1	0.29
1362	67-2	Early Mesilla(?)	H	5.6	0.33
2190	145-4	Early Mesilla(?)	H	6.3	0.49
1788	73-10	Early Mesilla and Late Archaic	H	4.0	0.44
1125	503-108	Late Mesilla	H	4.7	0.37
1125	503-138	Late Mesilla	—	XRF Only	—
1125	503-90	Late Mesilla	—	XRF Only	—
1125	503-91	Late Mesilla	—	XRF Only	—
2361	9-5	Mesilla and El Paso	L	4.2	0.25
2361	9-27	Mesilla and El Paso	L	3.3	0.30
2361	9-30	Mesilla and El Paso	M	2.7	0.47
2361	9-6	Mesilla and El Paso	L	2.6	0.56
2361	9-8	Mesilla and El Paso	L	2.2	0.42
2361	9-28	Mesilla and El Paso	L	No Rim	—
2361	9-7	Mesilla and El Paso	H	No Rim	—
1104	17-2.2	El Paso	L	2.3	0.40
1104	17-2.6	El Paso	L	2.7	1.07
1104	17-2.1	El Paso	L	No Rim	—
2364	187-3	El Paso	L	3.5	0.38
1107	17-1.2	El Paso	L	2.1	0.41
1107	17-19.4	El Paso	M	No Rim	—
1107	17-19.2	El Paso	H	2.7	0.51
1107	17-19.6	El Paso	H	3.6	0.82
1107	17-19.1	El Paso	H	No Rim	—
2490	186-8	Mesilla, El Paso, Middle and Late Archaic	M	2.8	0.33
2490	182-63	Mesilla, El Paso, Middle and Late Archaic	L	1.7	0.27
1795	63-8	Mesilla, El Paso, Middle and Late Archaic	L	4.5	0.73
1152	185-29	Mesilla, El Paso, Middle and Late Archaic	M	6.3	0.40
1152	185-16	Mesilla, El Paso, Middle and Late Archaic	H	6.1	0.41
1152	185-31	Mesilla, El Paso, Middle and Late Archaic	M	4.2	0.53
1203	76-7	Lithic and Ceramic Unknown	L	4.9	0.77
2661	189-1	Lithic and Ceramic Unknown	M	3.2	0.42
1366	31-2	Lithic Unknown	M	8.7	0.90
2321	128-6	Lithic Unknown	M	No Rim	—
2599	231-2	Lithic Unknown	H	2.0	0.27
2535	208-6	Lithic Unknown	H	3.9	0.61
1621	52-6	Lithic Unknown	H	7.5	0.54
1644	62-9	Lithic Unknown	H	No Rim	—
?	101-1	None	M	2.4	0.33
2490	504-56	Jay Point/Mid, Late, Post-Archaic	H	5.7	0.47
—	100-3	Armijo/Paisano	H	3.5	0.29
1467	75-3	Armijo/Paisano	H	No Rim	—
—	242-2	Dick No. 15	H	3.5	0.32
—	185-28	San Pedro	L	4.5	0.36
—	68-5	San Pedro	H	7.7	0.59

Table 11.6. (continued)

Site Number	Catalog Number	Associated Date(s)	Degree of Sandblasting	Depth	s
—	67-8	Martindale(?)	H	5.8	0.56
—	29-14	Ellis/Carrington	H	4.5	0.59
—	52-15	Ellis/Carrington	H	No Rim	—
—	507-1	Shumla Point/Late Archaic	L	7.3	0.66
—	144-5	Mid-Late Archaic	H	3.1	0.34
—	146-3	Mid-Late Archaic	H	No Rim	—
1126	503-37	Features Only(?)	—	XRF Only	—

Methodology

Prior to sample preparation for hydration rim measurement, all samples were categorized according to the observed intensity of sandblasting. These categories were based on the degree of pitting and frosting and the clarity of flake scars. Three categories were subjectively defined: (a) lightly sandblasted—these samples showed light pitting and frosting and still had a high degree of clarity of flake scars; (b) moderately sandblasted—these samples had moderate amounts of pitting and frosting and less clarity of flake scare; and (c) heavily sandblasted—these samples were heavily pitted and frosted and their flake scars were rounded and obscured. The samples were separated into three categories to represent the effect of sandblasting on the continuity, thickness, or presence of the hydration rim.

The samples were prepared generally by the methods outlined by Michels and Tsong (1980) and Michels and Bebrich (1971). Specific procedures used by OHL are discussed below.

The first step in the procedure was to apply isotropic epoxy to the surface of the obsidian sample. The obsidian was then heated in a kiln at 140 degrees F (60 degrees C) for two hours to ensure maximum cure. It has been demonstrated that the epoxy protects the hydration surface of the obsidian during sawing (Katsui and Kondo 1976).

Next, a wedge was cut from each sample by making two parallel cuts perpendicular to the edge of the artifact. An oil-cooled Raytech Trimsaw with a 4-in diamond-edged blade was used. The wedge was then removed from the

Table 11.7. Results of hydration analysis of nonlocal XRF group

Site Number	Catalog Number	Associated Date(s)	Degree of Sandblasting	Depth	s
Rio Grande Pleistocene terrace gravels (Las Cruces)					
2361	9-19	Mesilla and El Paso	M	2.2	0.34
1104	17-2.3	El Paso	L	1.4	0.24
1383	41-2	El Paso and Late Archaic	M	1.3	0.30
2654	251-22	Early Mesilla, El Paso, Middle, Mid-Late Archaic	H	4.2	1.08
—	19-3	Ellis/Carrington	H	4.1	0.32
2224	170-3	Lithic Unknown	H	3.2	0.57
Rio Grande Pleistocene terrace gravels (Cochiti)					
1896	502-19	Early Archaic	—	XRF Only	—
2361	9-11	Mesilla and El Paso	L	2.8	0.51
1107	17-19.5	El Paso	M	3.0	0.44
1091	64-4	Lithic/Ceramic Unknown	H	8.1	0.64
Rio Grande Pleistocene terrace gravels (Los Lunas)					
2490	504-24	Mid, Late, Post-Archaic	—	XRF Only	—
Red Hill, west central New Mexico					
1896	502-17	Early Archaic	—	XRF Only	—
1896	502-7	Early Archiac	H	No Rim	—
2490	503-59	Unknown Early Archaic Point, Paleo, Post-Archaic	H	4.2	0.57
1125	503-137	Late Mesilla	—	XRF Only	—
Polvedera Peak, Jemez Mountains					
—	121-6	San Pedro	L	No Rim	—

artifact with an "X-acto" knife and cleaned with soap and ethyl alcohol to remove any remaining traces of oil.

The initial grinding phase was begun by mounting the wedge onto a glass microscope slide. Lakeside thermoplastic (quartz) cement was used as a mounting medium. The catalog number of the sample was etched onto the slide to ensure that the provenience information was maintained. The wedge was ground to approximately half of its original thickness using a slurry of water and fine-grained corrundum grit. All grinding was done by hand on a glass plate using a "figure-8" motion.

After the wedge was ground halfway, the slide was cleaned to remove traces of grit, a pencil line was drawn on the wedge to mark the hydrated surfaces of the piece, and the wedge was turned over and remounted. A new slide was used and the wedge was mounted again with Lakeside thermoplastic (quartz) cement. The catalog number was etched onto the new slide as before. With the slurry of fine-grained corrundum grit and water the wedge was ground (in the same manner described above) to an approximate thickness of 0.003 in to maximize the optical qualities of the obsidian under the microscope.

The final stage of sample preparation was the application of the cover slip using heated Canada Balsam. The mounting medium was changed at this point simply because it was found that fewer air bubbles were created using the Canada Balsam during cover slip application.

Hydration rims were recorded using a Nikon Labophot POL petrographic microscope with polarized light (X-Nichols) and a 1/4 wave/red tint plate at 600 diameters. The tint plate creates a dark background upon which the hydration rim appears blue due to the difference in biorefrigence. Highlighting the rim helps to delimit the interior of the hydration rim, thus making measurements more accurate.

All measurements were done with a filar eyepiece interfaced with a TI-50 calculator for automatic data recording. At the beginning of each measurement session the optics of the microscope were calibrated against a standard to account for changes in barometric pressure and temperature. Measurements were taken by two observers. Exterior sides of the sample were scanned to find the widest and narrowest portions of the hydration rim. Each observer made five measurements at five different locations. The 10 measurements were then averaged and the standard deviation and depth of hydration rim in microns were calculated. The two observers worked no more than four consecutive hours to reduce the chance of error due to eye strain. In cases where neither observer could identify a rim, a third observer was asked to examine the slide. If no rim was found by the third observer, a second slide was prepared and the entire procedure was repeated. If no rim was observed on the second slide, it was assumed that there was none present on the sample.

All measurements and calculations were recorded on OHL data sheets. Other notable optical observations (e.g., hydration rims along cracks and quality of the hydration rim) were also recorded.

Observations

When samples of Tularosa Basin obsidian from single component sites are considered, the general decrease in mean rim depth agrees with relative ceramic chronological ordering. The average rim depth for Early Mesilla phase sites (1388, 1231, 1667, 1362, and 2190) is 4.62 microns. In contrast, the average rim depth for Mesilla/El Paso and El Paso phase sites is 2.9 microns. If these trends are reliable, Site 1125, which has been interpreted as a Late Mesilla phase site, may be an Early Mesilla phase site, as may Site 1788 (rim depths of 4.7 and 4.0 microns respectively).

Samples of Tularosa Basin obsidian from sites that have been assigned to occupations from Middle Archaic through El Paso phases exhibit a wide range of rim depths (6.3–1.7 microns). Rim depths of the three samples from Site 1152 suggest that they relate to the Archaic and Mesilla phase occupations of the site. The two samples from Site 2490 have rim depths indicating that these samples probably relate to the El Paso phase occupation of the site.

Four of the eight sites described as either lithic and ceramic unknown or lithic unknown (sites 1203, 2661, 2599, and 2535) have rim values suggesting Mesilla through El Paso phase occupations. Of the remaining four unknown sites, two (1644 and 2321) exhibited no rims and two (1366 and 1621) exhibited rim depths suggesting preceramic lithic sites.

Summary

Phase II XRF analyses are quite similar to those of Phase I. A majority of the obsidian artifacts recovered as part of the Border Star 85 project were derived from local sources in the Tularosa Basin or from the Pleistocene river gravels east of the basin. A few pieces were brought into the basin from areas to the north (Los Lunas and Cochiti gravel, Red Hill, and Jemez sources).

Obsidian hydration rim depth showed relatively consistent patterning with associated dates and may be useful in placing sites without associated dates into a relative sequence. It should be recognized, however, that in doing so, one assumes contextual contemporaneity between the obsidian sample and other artifacts.

No consistent pattern was discernible between the subjective categories of sandblasting and rim depth. We suspect that sandblasting has affected the rim depth; however, the subjective methods used to categorize the degree of weathering may not have been sensitive enough to elucidate any relationship that might exist. It is also possible that the mixing of materials from components or repeated occupations has obscured the relationship between degree of sandblasting and rim depth. To further clarify this relationship we suggest refining the sandblasting categorization in future investigations and exploring the comparisons among single component sites with chemically similar obsidians.

Chapter 12

CERAMIC TYPOLOGY

Barbara J. Mills

This chapter summarizes the variables recorded for ceramic artifacts during the Border Star 85 project conducted by the Office of Contract Archeology, University of New Mexico. The chapter is organized into two sections. First, the sample selection and variables recorded are briefly discussed. Second, the taxonomic system used in ceramic identifications is outlined and occurrence frequencies by ceramic category are presented. In addition, methodological and theoretical problems in applying this taxonomy are outlined and estimated dates of occurrence are suggested for each taxonomic category.

Sample Selection and Variable Coding

The ceramic sample was recorded as part of both Phase I and Phase II activities of the Border Star 85 project. Ceramic recording was conducted at several levels, including both in-field coding and laboratory analyses of collected artifacts.

Each ceramic artifact was coded in the field by ceramic type and locational parameters. For 96.5 percent of the 19,229 ceramics encountered in the survey sample units, this was the only attribute coding conducted and the artifacts were not collected. The other 3.5 percent (677) ceramic artifacts were collected and an additional set of attributes was recorded. Artifact collections were made when the sherd displayed some portion of the rim of the vessel, or when the field recorder was not sure of the taxonomic identification.

Laboratory analysis proceeded in two stages. First, Roger Anyon identified ceramic type and vessel form for each of the collected ceramics. For some sherds this was the first entry of these attributes into the data base, but for others it was not. When Anyon's identifications differed from those made in the field, his identifications took precedence and the data base was modified.

The second stage of laboratory analysis treated a more limited sample but involved several attributes not previously recorded. This analysis was conducted by the author on a sample of 485 rim sherds. Ceramic type and vessel form identifications were checked again, and the additional attributes of rim eversion and wall thickness were recorded. The sample of sherds analyzed at this stage consisted of all collected rim sherds of painted and unpainted El Paso Brownware. Both bowls and jars were included in the analysis. Rim eversion was measured in 10-degree intervals, with the interior of the rim facing the low end of the scale. Wall thickness was measured in two places with digital calipers: at 2 and 15 mm below the lip of the rim, except for thickened rims, which were measured at their maximum and minimum rim thicknesses as described by Carmichael (1983). This analysis is outlined in Chapter 13.

Ceramic Typology

The ceramic types recorded during Phase I and II survey are listed in Tables 12.1 and 12.2, along with their frequency of occurrence. Two totals are shown in these tables: one for all ceramics recorded on the project, and one for all collected ceramics. Each category is described below and estimated dates of production for each are summarized in Table 12.3.

El Paso Brownware

Unspecific El Paso Brown. Most of the El Paso Brownware was placed in this category when both paint and the diagnostic vessel portion necessary to identify true El Paso Plain Brown (the rim) were absent. The use of this category follows that of Anyon (1985), Hard (1983b), Whalen (1977, 1978, 1980), and others, who have noted that if the rim is not present, it is virtually impossible to differentiate among El Paso Plain Brown, El Paso Bichrome, and El Paso Polychrome. The latter two types are painted primarily around the rim and neck area (Runyon and Hedrick 1973; Stallings 1931). Thus, with body sherds, the term Unspecific El Paso Brown is used in order to preserve the analytical integrity of the El Paso Plain Brown category. The category of Unspecific El Paso Brown potentially may contain sherds from any of the El Paso Brownwares and is therefore not very useful for chronological control.

El Paso Plain Brown. As noted above, sherds were assigned to this category only if they were unpainted rim sherds with the characteristic large-tempered El Paso Brownware paste. Both bowls and jars were present, with the latter predominating. Rim shape indicates that neckless forms are the most common jar shape. Vessels of this type were apparently made for a long period of time in the El Paso area. Recent radiocarbon dates associated with ceramics of this type suggest that El Paso Plain Brown began to be produced as early as AD 300, if not a century earlier (Whalen 1981a). O'Laughlin (1985) has challenged this early date, pointing out that the few radiocarbon dates obtained are from hearths where the temporal association of the brownware sherds with the carbon samples cannot be proven.

Table 12.1. Ceramic type frequencies for all recorded and all collected ceramics: Phase I

	All Recorded		All Collected	
Ceramic Type	Number	Percent	Number	Percent
El Paso Brownware				
Unspecific El Paso Brown	15,988	83.15	26	4.60
El Paso Plain Brown	263	1.37	137	33.51
El Paso Bichrome	391	2.03	60	10.75
El Paso Polychrome	1,035	5.38	139	24.91
Other Brown				
Plain Other Brown	596	2.96	26	4.66
Textured Other Brown	6	0.03	1	0.18
Corrugated Other Brown	16	0.08	3	0.54
Smudged Other Brown	2	0.01	1	0.18
Chupadero				
Chupadero B/W	558	2.90	26	4.66
Three Rivers Redware				
Undiff. Red/T-C	34	0.18	11	1.97
Lincoln B/R	2	0.01	2	0.36
Mimbres Whiteware				
Three Circle R/W	7	0.04	1	0.18
Boldface B/W (Mimbres Style I)	3	0.02	1	0.18
Transit. B/W (Mimbres Style II)	32	0.17	2	0.36
Classic B/W (Mimbres Style III)	44	0.23	20	3.58
Unknown Mimbres B/W	82	0.43	18	3.23
Other Wares				
San Francisco Red	12	0.06	0	
Mogollon Red/Brown	6	0.03	0	
Magdalena B/W (?)	11	0.06	5	0.90
Playas Red	26	0.14	3	0.54
Undiff. Mexican Poly	13	0.07	6	1.08
Undiff. White Mt. Redware	10	0.05	5	0.90
Agua Fria Glaze/Red	1	0.01	1	0.18
Tucson Polychrome	1	0.01	1	0.18
Undiff. Slipped Redware	12	0.06	11	1.97
Unknown	105	0.55	2	0.36
Total	19,229	100.00	558	100.00

Whalen (1981a) also notes that El Paso Plain Brown continued to be produced until ca. AD 1100, when it was replaced by El Paso painted types. The replacement of a plain type by a painted type is interesting because in most other areas of the Southwest plainwares continued to be made along with additional painted types. The apparent lack of temporal overlap in the El Paso area between these two general classes suggests two things: either the dating of El Paso Plain Brown should be extended later in the sequence, or the use of painted ceramic vessels in the El Paso area was quite different from that in other areas of the Southwest, even within the Mogollon. Although there are no data from excavated contexts that would support the extension of El Paso Plain Brown much past AD 1200, this type regularly co-occurs with other early El Paso phase ceramic varieties (e.g., Chupadero Black-on-white, Three Rivers Redware, and Playas Red) within the Border Star 85 sites. For this reason, El Paso Plain Brown was seen as common to all Formative period assemblages.

El Paso Bichrome. This category comprises sherds of El Paso Brownware with either red or black paint, but not both. In some classifications the specific types of El Paso Black-on-brown and El Paso Red-on-brown are used (e.g., Runyon and Hedrick 1973), but the two were combined in the analysis here. Whalen (1978) lumps this category with "Later El Paso Brown," despite the presence of paint.

This category may contain sherds of El Paso Polychrome. In fact, owing to the rarity of whole vessels with only one paint color, it is highly probable that there are many misclassified El Paso Polychrome sherds in the bichrome category. Whole vessels of El Paso Red-on-brown are present in museum collections (Robert J. Hard, personal commu-

Table 12.2. Ceramic type frequencies for all recorded and all collected ceramics: Phase II

	All Recorded		All Collected	
Ceramic Type	Number	Percent	Number	Percent
El Paso Brownware				
Unspecific El Paso Brown	8411	95.78	4	3.01
El Paso Plain Brown	114	1.30	112	84.21
El Paso Bichrome	23	0.26	4	3.01
El Paso Polychrome	28	0.32	4	3.01
Other Brown				
Plain Other Brown	148	1.69	2	1.50
Textured Other Brown	0		0	
Corrugated Other Brown	0		0	
Smudged Other Brown	0		0	
Chupadero				
Chupadero B/W	8	0.09	0	
Three Rivers Redware				
Undiff. Red/T-C	0		0	
Lincoln B/R	0		0	
Mimbres Whiteware				
Three Circle R/W	0		0	
Boldface B/W (Mimbres Style I)	3	0.03	1	0.75
Transit. B/W (Mimbres Style II)	5	0.06	0	
Classic B/W (Mimbres Style III)	4	0.05	2	1.50
Unknown Mimbres B/W	31	0.35	2	1.50
Other Wares				
San Francisco Red	3	0.03	0	
Mogollon Red/Brown	1	0.01	0	
Magdalena B/W (?)	0		0	
Playas Red	0		0	
Undiff. Mexican Poly	0		0	
Undiff. White Mt. Redware	0		0	
Agua Fria Glaze/Red	0		0	
Tucson Polychrome	0		0	
Undiff. Slipped Redware	0		0	
Unknown	3	0.03	2	1.50
Total	8782	100.00	133	100.00

nication 1985), however, indicating that this taxonomic category is not a complete case of mistaken identity.

The dating of El Paso Bichrome is highly uncertain owing to the rarity of examples that are definitely not El Paso Polychrome. Based on similarities in rim morphology, this type has been suggested to overlap temporally with El Paso Plain Brown on the early end and with El Paso Polychrome on the later end (Whalen 1981a:Fig. 7). Whalen (1978:63) notes a radiocarbon date of AD 1000 associated with the "later El Paso Brown variant," some of which would be called El Paso Bichrome here.

El Paso Polychrome. This type has the distinctive coarse El Paso Brownware paste decorated with both black and red matte paints, occasionally underlain by a thin red wash or slip (Stallings 1931). Jars with a diversity of neck shapes, including direct and everted, and hemispherical bowls are present. There is increasing evidence that this painted type was used for cooking, based on the presence of exterior carbonization (Wiseman 1984).

Early and late or "classic" variants of El Paso Polychrome have been suggested (Way 1979; Whalen 1981a) based on differences in rim and neck shape and ceramic associations. The association with Mimbres Black-on-white has suggested to Way (1979) that the early straight-necked variant dates to ca. AD 1100–1250. Except for one date in the mid-1100s, all associated chronometric dates for any El Paso Polychrome postdate AD 1200 (Whalen 1981a). Early and late variants of El Paso Polychrome were not monitored during field analysis, however, El Paso Brownware rims were collected and subjected to a quantitative analysis of rim shape (Chapter 13).

Table 12.3. Estimated dates of production for ceramic types in Border Star 85 sample

Ceramic Type	Estimated Dates (AD)*		Reference
El Paso Brownware			
Unspecific El Paso Brown			
El Paso Plain Brown	400+	to 1100+	Whalen 1981a
El Paso Bichrome	800	to 1100	Whalen 1981a
El Paso Polychrome	1100+/−	to 1400	Whalen 1981a
Other Brown			
Plain Other Brown			
Textured Other Brown			
Corrugated Other Brown			
Smudged Other Brown			
Chupadero			
Chupadero B/W	1175+/−	to 1545	Hayes et al. 1981
Three Rivers Redware			
Undiff. Red/T-C	1150+/−	to 1300+	Stewart 1983
Lincoln B/R	1300+	to 1400+	Stewart 1983
Mimbres Whiteware			
Three Circle R/W	750	to 800	Anyon 1980
Boldface B/W (Style I)	750	to 1000	Anyon 1980
Transit. B/W (Style II)	850	to 1050	Anyon 1980
Classic B/W (Style III)	1000	to 1150+	Anyon 1980
Unknown Mimbres B/W			
Other Wares			
San Francisco Red	550	to 100	Anyon 1980
Mogollon Red/Brown	650	to 750	Anyon 1980
Magdalena B/W (?)	1200+/−	to 1350+/−	Knight and Gomalak 1981
Playas Red	1150+	to 1400	Mills 1984a
Undiff. Mexican Poly			
Undiff. White Mt. Redware	1050	to 1275	Carlson 1970
Agua Fria Glaze/Red	1325	to 1425+	Cordell and Earls 1984
Tucson Polychrome	1275	to 1400	Hayden 1957
Undiff. Slipped Redware			

*The symbols "+" or "+/−" indicate dates that are more problematic than the others. While all of these dates are to some extent approximated, those tagged are more so.

**An attempt has been made to use references to recent publications that either contain new dates or provide recent assessments of the chronological placement of the listed ceramic category.

Other Brownware

Brownwares that did not have the characteristic large-grained temper of El Paso Brownware were classified separately under Other Brownware. Several different categories were distinguished within this general class, based on differences in surface treatment: plain, corrugated, textured, and smudged. Most of the brownware in these categories is probably of the Alma series. Dates have not been assigned to these categories owing to the uncertainty in their identification.

Chupadero Whiteware

Chupadero Black-on-white was the most prevalent painted type other than El Paso Brownware recorded during the project, representing nearly 3 percent of the total ceramic sample. This type was identified on the basis of its distinctive homogeneous gray paste and black igneous temper. Deep scoring of the unpainted surface is often present on sherds of this type (Mera 1931), although this scoring does not have to be present in order for a sherd to be assigned to this category. As Runyon and Hedrick (1973) point out, only about one-half of the Chupadero Black-on-white identified at the site of Gran Quivira was scored. Chupadero Black-on-white has a high degree of functional specificity; although bowls are present, jars are most prevalent in El Paso area assemblages (Smiley 1977). The jar forms usually have highly restricted orifices and were probably used to carry water (Wiseman 1984).

Unfortunately, although Chupadero is a widespread tradeware, it is not well dated. Hayes estimates that the type dates to ca. AD 1175–1545 (Hayes et al. 1981). The later

end of this estimate is confirmed by chronometric dates from Mound 7 at Gran Quivira, but the beginning of production is an estimate based on cross-dating with types from neighboring areas. Unfortunately, this beginning date hinges on the dating of Mimbres Black-on-white, a type whose chronological position may be less well known outside of the Mimbres Valley than previously thought (see discussion of this type below). Given the current data, Chupadero may have been first produced virtually anytime during the AD 1100s.

Three Rivers Redware

Unidifferentiated Red-on-terracotta. This category potentially combines both San Andres Red-on-terracotta and Three Rivers Red-on-terracotta. Following Wimberly and Rogers (1977) in part, the two have been combined because of the difficulty in distinguishing what are apparently stylistic variants of technologically similar types.

Stewart's (1983) recent review of the dating of Three Rivers Redware suggests that Three Rivers Red-on-terracotta dates to ca. AD 1150–1300. Dates for the other type subsumed here within the Undifferentiated Red-on-terracotta category (San Andres Red-on-terracotta) are not well known. Even one of the earliest descriptions of this type (Mera and Stallings 1931) notes that the two Red-on-terracotta types may have considerable temporal overlap. Suggestions of the temporal precedence of San Andres Red-on-terracotta were largely due to perceived similarities between this type and the early painted type of Mogollon Red-on-brown. But in a recent review of the Mogollon ceramic sequence by LeBlanc (1982), the suggested similarity between the two types has been challenged. It seems most likely that the two Red-on-terracotta types may be safely grouped together and that neither dates much earlier than AD 1100.

Lincoln Black-on-red. Except for paint color, this type is very similar to the Red-on-terracotta sherds discussed above, but instead of a red paint, a black, often glazed paint was used. The distinctive terracotta paste is still present. The reddish surface color has been described as a float, not a true slip by Mera and Stallings (1931), who also note that bowl forms are predominant. Lincoln Black-on-red probably overlaps in time with the earlier Red-on-terracotta category. Stewart (1983) suggests that the period of overlap is approximately 50–100 years and that the best dates for this type are from the early to mid-1300s to 1400 or possibly 1450.

Mimbres Whiteware

Three Circle Red-on-white is the first white-slipped type made in the Mimbres area, temporally and stylistically following Mogollon Red-on-brown. Although called a whiteware, its slip tends to be of a cream color or, occasionally, buff. The exterior of sherds of this type has the same dimpling as Mogollon Red-on-brown. This attribute, along with the evidence of polishing over the red paint, helps to differentiate this type from later Mimbres Whitewares, which may often appear to be painted red as a result of misfiring. Three Circle Red-on-white was made in both bowl and jar forms, but even in its assumed area of production this type does not occur in very high frequencies (Anyon and LeBlanc 1984). It has been dated by Anyon (1980) to AD 750 to 800.

The other Mimbres Whiteware types were more numerous than Three Circle in the Border Star 85 project area. Following recent reevaluations of the Mimbres Whiteware sequence (Anyon 1980; Anyon and LeBlanc 1984; Scott 1983), three styles of Mimbres Whiteware were distinguished on the basis of certain design elements, design layout, and framing line width. Of the three styles, Boldface Black-on-white (Style I) was present in the lowest frequencies. Its successor, called Transitional Black-on-white (Style II) was much more prevalent. Classic Black-on-white (Style III) was most numerous. All of these styles predominantly occur on bowl forms.

Based on revisions to the Mogollon-Mimbres phase sequence (Anyon et al. 1981), Anyon (1980) has suggested that Style I dates to AD 750–1000, Style II to 850–1050, and Style III to 1000–1150. The revisions to the sequence have been based on chronometric dates obtained from excavations in the Mimbres Valley. The AD 1150 ending date for Style III—Classic Black-on-white—is based on the lack of chronometric dates from Mimbres Valley sites after AD 1130.

While these dates fit with the Mimbres Valley data, the AD 1150 ending date for Classic Black-on-white is problematic for Jornada Mogollon assemblages because Classic Black-on-white frequently occurs with three types that have all been assigned beginning dates of ca. AD 1150: El Paso Polychrome, Chupadero Black-on-white, and Three Rivers Red-on-terracotta. Even within areas of the Mimbres-Mogollon outside the Mimbres Valley, the co-occurrence of these types has been frequent enough to lend doubt to the AD 1150 cutoff date for Classic Black-on-white and/or the 1150 beginning date for the three Jornada types (Mills 1984a). Unfortunately, the few chronometric dates available do not help determine whether the dating of Classic Black-on-white should be extended as a locally manufactured ware to the late AD 1100s, as suggested by Carmichael (1983) and Laumbach and Kirkpatrick (1983), or whether the beginning of production of the three Jornada types should be placed in the early 1100s. For the southern Jornada area, this is a particularly acute problem because all of these types overlap during the time period that has been proposed to represent a separate developmental phase—the Doña Ana phase (Carmichael 1983; Lehmer 1948). Petrographic study of a sample of the Border Star 85 Mimbres ceramics (Chapter 14) also addresses this problem. Until more dates from the twelfth century are secured, this will remain a problem.

Other Wares

Most other wares were recorded only in small frequencies. Yet because several of them are relatively well dated, they may be important for ceramic cross-dating efforts.

Two early Mogollon types, San Francisco Red and Mogollon Red-on-brown, were identified. The former label was only applied if the diagnostic exterior finger dimpling was present, in addition to a well-polished red slip. All other undecorated red-slipped ware was placed in the category of undifferentiated slipped redware. San Francisco Red

had a long time range during the Pithouse period: from ca. AD 550 to 1100 (Anyon 1980). Mogollon Red-on-brown is technologically similar to San Francisco Red, except that red is used as a paint rather than a slip. The vessels are also well-polished over the paint. This type has been dated to ca. AD 650–750, during the San Francisco phase in the Mogollon-Mimbres area (Anyon 1980; Anyon et al. 1981).

Several sherds of a carbon-painted black-on-white type were identified. Small frequencies of these sherds are commonly encountered in assemblages in the southern Jornada area (e.g., Carmichael 1983; Lehmer 1948) and northern Mexico (DiPeso et al. 1974). Following Lehmer (1948), these authors have called the carbon-painted type Galisteo Black-on-white. At the time of Lehmer's fieldwork the Galisteo area was the closest known area where a carbon-painted black-on-white type was distributed. But since then, other abundant quantities of carbon-painted ceramics have been reported closer to the southern Jornada area, including just northwest of Magdalena (Knight and Gomalak 1981; Warren 1974). Based on large samples from excavations at Gallinas Springs Pueblo (LA 1178), Knight and Gomalak (1981) have named this carbon-painted ceramic Magdalena Black-on-white. Carbon-painted black-on-white sherds fitting this description have been recorded at several sites in western Sierra County (Mills 1984a), and it seems likely that this same type is found in the El Paso area as well. The name Magdalena Black-on-white has been applied to the carbon-painted ceramics recorded during the Border Star 85 project, although more research, preferably on paste composition, should be performed to determine if they are indeed the same.

Through ceramic cross-dating, Knight and Gomalak (1981) estimate that Magdalena Black-on-white dates to the AD 1200s, with possible extensions both earlier and later. In western Sierra County this type is associated with Mimbres Black-on-white, Chupadero Black-on-white, El Paso Polychrome, and St. Johns Polychrome, also suggesting a date range in the AD 1200s (Mills 1984a), with a possible extension on the early end into the late 1100s.

Chihuahuan ceramics present in the Border Star 85 sample were classified into two categories: Playas Red and undifferentiated Chihuahuan Polychromes. Chihuahuan Polychromes were not differentiated and are therefore not very useful for chronological control. Playas Red was identified if one of the distinctive textured surface treatments was present, as described by Rinaldo (1974). Recent temper analyses reported by Wiseman (personal communication 1986) have separated a Sierra Blanca variety of Playas Red, indicating that this type may not necessarily have been made in Chihuahua.

Playas Red occurs within Medio period contexts at Casas Grandes, originally dated to AD 1060–1340 by DiPeso and others (1974), but recent reevaluations of these dates suggest that this phase began no earlier than 1130 or 1150 (LeBlanc 1980) and may have lasted until the early 1400s (Lekson 1984). In western Sierra County assemblages, Playas Red occurs with post-Classic Mimbres types dating to the AD 1200s, such as St. Johns Polychrome and Tularosa Black-on-white (Mills 1984a). Thus, Playas Red is generally thought to begin ca. AD 1200 and extend through the 1300s.

White Mountain Redware types were not differentiated in the field, although at least two of those represented in the collected ceramic sample are St. Johns Polychrome. All of the types of this ware postdate AD 1050 (Carlson 1970). The end date of AD 1275 is used because St. Johns is the latest matte-painted White Mountain Redware, and no glaze-painted types of this ware were reported.

At least one sherd each of two additional nonlocal types was identified: Agua Fria Glaze-on-red and Tucson Polychrome. The former type has traditionally been viewed as one of the earliest glazewares in the Rio Grande sequence. A recent reevaluation of this and other Glaze A types suggests that this typological group may have been made later than the AD 1325–1425 period previously assigned to it, perhaps even into the sixteenth century (Cordell and Earls 1984). Tucson Polychrome, also identified in the Border Star 35 collections, overlaps with this range. Hayden (1957) dates this type to ca. 1275–1400 based on its stylistic similarity to Kayenta and Four Mile Polychromes, as well as tree-ring dated proveniences.

Chapter 13

EL PASO BROWNWARE RIM ANALYSIS

Timothy J. Seaman and Barbara J. Mills

In 1948 Lehmer noted important differences in rim forms of El Paso Brownware. Recent research suggests that these differences have chronological significance and, further, that they may be measured using a rim thickness index. This chapter applies rim thickness indices to El Paso Brownware from the Border Star 85 survey. Changes in the rim thickness index through time are confirmed for the Border Star 85 sample, and some refinements to the measure are suggested; however, it is also pointed out that while chronological differences are apparent, they must be looked at in light of what is being measured: changes in vessel form. Implications for changes in vessel use through time are explored.

Background on the Rim Sherd Index

Ever since Lehmer's (1948) classic work defining the Jornada area, variation has been recognized in the morphology of different types of El Paso Brownware. Lehmer suggested that these morphological differences were temporally sensitive, and they were incorporated into his phase designations for the Jornada area. In particular, he proposed that the Doña Ana phase (AD 1100–1200) could be ceramically distinguished from the succeeding El Paso phase based on changes in the rim profiles of El Paso Polychrome sherds.

Although Whalen (1977, 1978, 1980) did not use Lehmer's Doña Ana phase concept, he noted similar trends through time in the rim and neck morphology of El Paso Brownware. In attempting to refine the chronology of El Paso Brownware, Whalen (1978; 1981b) proposed a tentative developmental sequence of rim and neck forms for El Paso Brown and El Paso Polychrome. This qualitative sequence begins at ca. AD 400–700 with an inverted neck and pinched rim, mostly found on plainware vessels. It then proceeds to a more even-walled but still inverted neck form, then to a slightly thickened and direct neck, and finally to a thickened and everted neck. Only the pinched inverted form was suggested to occur solely as a plainware. All other forms were at least occasionally painted, with the latter two stages in the sequence nearly always occurring on El Paso Polychrome.

In a subsequent report using the same data base, Whalen (1980) suggested that mean rim diameter changes were also correlated with the developmental sequence outlined earlier. Statistically significant increases in rim diameter were noted to be present between the pithouse and pueblo samples. In addition, mean wall thickness was tested and found to decrease significantly after the pithouse period.

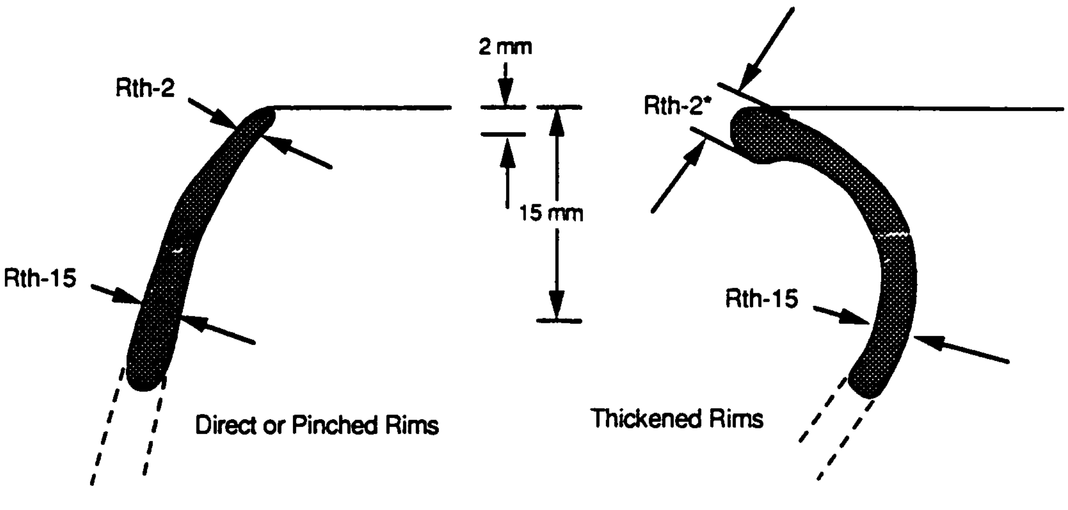
In a further attempt to find a means for assessing chronological placement of the El Paso Brownware types, West (1981) developed what was termed the rim sherd index (RSI) to measure the changes discussed by Whalen. Although more properly a rim *thickness* index, the original terminology will be retained here for the sake of consistency. As discussed in Carmichael's (1983:76–77) report, this index uses two measurements of wall thickness, one each at 2 and 15 mm (Figure 13.1). The index is calculated with the 2 mm measurement as the numerator and the 15 mm measurement as the denominator. The index was developed to make objective observations on changes in rim finish, i.e., Whalen's pinched, flattened, and thickened attribute states. In cases where the rim is thickened, the 2 mm thickness measurement is taken at the point of maximum rim thickness, and the 15 mm measurement at the point where rim thickening ends. West (1981) tested the index against two chronometrically dated assemblages and found a statistically significant difference in the means of the two assemblages.

The RSI, as it was originally used by West, apparently grouped all vessel forms and all types of El Paso Brownware together. Carmichael's (1983, 1985) contribution was to separate El Paso Brown from El Paso Bichrome and Polychrome, with some statistical improvement in the results. In Carmichael's analyses, a mean index was derived for each type. When mean indices for El Paso Brown were compared for sites assigned to the Mesilla phase with those of the Doña Ana phase, a significant difference was apparent, as it was in the comparison of El Paso Polychrome mean indices between Doña Ana and El Paso phase sites.

In both West's and Carmichael's analyses, bowls and jars were apparently analyzed together. This combining of the analyses could be a significant problem and may affect the interpretability of the results since the sequence discussed by Lehmer and Whalen primarily refers to jar forms. In fact, Carmichael does recognize this problem: "none of the discussions of El Paso Brownware rim forms have explicitly controlled for vessel form, site type, etc." (1983:78).

In the Border Star 85 analyses the two general forms, bowls and jars, were analyzed separately. This was necessary because it cannot be assumed that changes in bowl rim morphology parallel those of jars. In fact, it is shown here that significant differences exist between the two general vessel forms of El Paso Brownware.

Another difference between the Border Star 85 and previous analyses of RSI is that an additional attribute was recorded—rim eversion, along an interval scale. This attribute was chosen because previous discussions of the



Rim Sherd Index=Rth-2/Rth-15

Rth-2=rim thickness in mm @ 2 mm below rim
Rth-2*=Maximum rim thickness in mm
Rth-15=Rim thickness in mm @ 15 mm below rim

Pinched rims= <1.0 RSI
Direct rims= ±1.0 RSI
Thickened rims= >1.0 RSI

Figure 13.1. Computation of the Rim Sherd Index (RSI)

changes in El Paso Brownware rims have consistently mentioned two attributes: rim eversion and rim finish. The latter is what is really being measured by the RSI. Although it is correlated with rim eversion, the RSI only measures the degree of thickening or pinching present. While the rim finish may indeed be the temporally sensitive variable, it is rim eversion that best describes the *shape* of the neck. This variable is important because neck shape is a better indicator of overall vessel form and, therefore, of possible functional differences. It also allows for more refined categories of vessel form to be considered in the analysis.

We see several problems with previous RSI analyses and other rim sherd studies (including our own). These problems generally fall into two categories: those of logic and those of comparability.

First, there has been very little absolute chronological control in characterizations of assemblages of brownware rims. Most rim sherd studies have focused on assemblages, known only through surface survey, which had been dated on the basis of simple presence/absence criteria among a variety of local and intrusive ceramic types. The works of West (1981) and Whalen (1980:Appendix A, 31–40) have isolated a small number of ceramic assemblages with absolute dates and have characterized rim and vessel forms as preliminary dating criteria, but as Whalen notes, "all that had been done . . . was to isolate two points on a continuum of ceramic change" (1980:34). This situation has led to a certain amount of circularity in the use of brownware rim characteristics as a dating tool. Rims are commonly used in conjunction with presence/absence ceramic type criteria as a means of placing assemblages into phases. This is especially true in the case of Early/Late Mesilla phase sites containing only El Paso Plain Brown sherds and Doña Ana phase sites containing a minimum of other temporally diagnostic types. In the former case "pinched" rims are treated as diagnostic indicators, while "direct" or "flattened" rims are treated as characteristic of the latter. The circularity arises when the rim forms from these assemblages are subsequently averaged or summarized to demonstrate the validity of using rim sherds for dating in the first place (i.e., that a pattern does exist) and central tendencies for each temporal unit are published as characteristic or representative values (e.g., Whalen 1980:31–44).

Second, there has been a general lack of agreement among researchers concerning what and how measurements should be made in order to monitor rim form variability. Approaches have varied from quantitative ones, such as West's (1981) and Carmichael's (1983, 1985) RSI studies, to the largely qualitative classifications of rim form used by

Whalen (1978, 1980). These analyses are not comparable, and truly regional studies—which are crucial to developing chronological tools—remain out of reach in spite of the considerable amount of territory that has been surveyed in south-central New Mexico during the last 10 years.

A further inconsistency in taxonomic matters deals with the placement of El Paso Brownware sherds with one color of paint. For example, Whalen (1978) apparently grouped sherds of this description with El Paso Plain Brownware. Our analyses show that if any grouping is to be done, bichrome sherds are best placed in the same category with El Paso Polychrome sherds. Since the red paint on polychrome sherds is often fugitive, these sherds may be easily misclassified as bichromes, especially when they are weathered from surface exposure.

Finally, there has been little effort to explore the functional reasons for the demonstrated changes through time in rim and/or vessel form. Insofar as vessel form is related to the use of ceramic containers for storage, preparation, or processing activities, it may be possible to extract far more information from the study of rim and vessel form than has been attempted thus far. The relative temporal information encoded in vessel rims should be seen as incidental to the potential functional information on the ceramic-using systems of the Formative period. Put another way, change in rim and vessel form through time is a phenomenon in need of explanation, and its effective use as a chronological indicator is largely a function of how well it is understood in functional terms. Thus, in this chapter we address the utility of the RSI for identifying chronologically significant differences among the Border Star 85 ceramic assemblages, and then we address what these differences may mean for changes in overall vessel form and, hence, vessel use.

The Data Base

The data base used in this analysis is the subset—totaling 485 sherds—of El Paso Brownware rims from the larger assemblage of ceramics collected during the Border Star 85 survey (see Tables 12.1, 12.2 and Appendix 8). All El Paso Brownware rim sherds located within the Phase I Transect Recording Units were collected for this study; the TRUs represent approximately 6 percent of the total project area. El Paso Brownware rim sherds collected during the intensive Phase II survey were added to the data base for analysis; these sherds represent all of the brownware rims from ca. 1.26 sq km of the project area. A breakdown of the data base by vessel form and ceramic type appears in Table 13.1.

As outlined in Chapter 2, the Phase I survey did not focus on site assemblages. Chapters 7 and 8 have demonstrated that estimates of site content based on the Phase I survey data are unreliable—especially in the case of small sites. A major portion of this study therefore deals with the Border Star 85 collections as a sample of the population of all brownware ceramics within the survey area rather than as a sample of site assemblages.

Table 13.1. Border Star 85 brownware rims: Ceramic type by vessel form

Ceramic Type	Vessel Form			
Frequency Percent Row Pct Col Pct	Bowl	Indet	Jar	Total
El Paso Brown	36 7.42 11.88 48.65	48 9.90 15.84 87.27	219 45.15 72.28 61.52	303 62.47
El Paso Bichrome	16 3.30 25.40 21.62	5 1.03 7.94 9.09	42 8.66 66.67 11.80	63 12.99
El Paso Polychrome	22 4.54 18.49 29.73	2 0.41 1.68 3.64	95 19.59 79.83 26.69	119 24.54
Total	74 15.26	55 11.34	356 73.40	485 100.00

Analytical Methods

The following variables were monitored during the analysis of El Paso Brownware rims:

1) **Ceramic Type/Ceramic Group**
   Ceramic type:
   - El Paso Brown (unpainted)
   - El Paso Bichrome (red or black on brown)
   - El Paso Polychrome (red and black on brown)

   Ceramic group:
   - Plain brownware (El Paso Brown)
   - Painted brownware (El Paso Bichrome/Polychrome)
2) **Vessel Form** (Figure 13.2)
   Jars
   Bowls
   Indeterminate forms
3) **Rim Eversion/Rim Form** (Figure 13.3)
   Rim eversion in 10-degree intervals
   Rim form:
   - Inverted rims (<80 ... e eversion)
   - Direct rims (80- ... ree eversion)
   - Everted rir ... egree eversion)
4) **Rim Sherd Index (RSI) or Rim Thickness Index (RTI)** (Figure 13.1)
   Rth2 (rim thickness in mm, 2 mm below rim)
   Rth15 (rim thickness in mm, 15 mm below rim)
   (also a measure of body wall thickness)
   SI (Rth2/Rth15)

The Rim Sherd Index (RSI) was treated as the dependent variable while the other variables were considered as independent factors. The basic questions asked of these data concern the correlation of RSI with ceramic type classifications and vessel or rim form categories. The initial focus of the study was to explore these relationships without controlling for chronological variability.

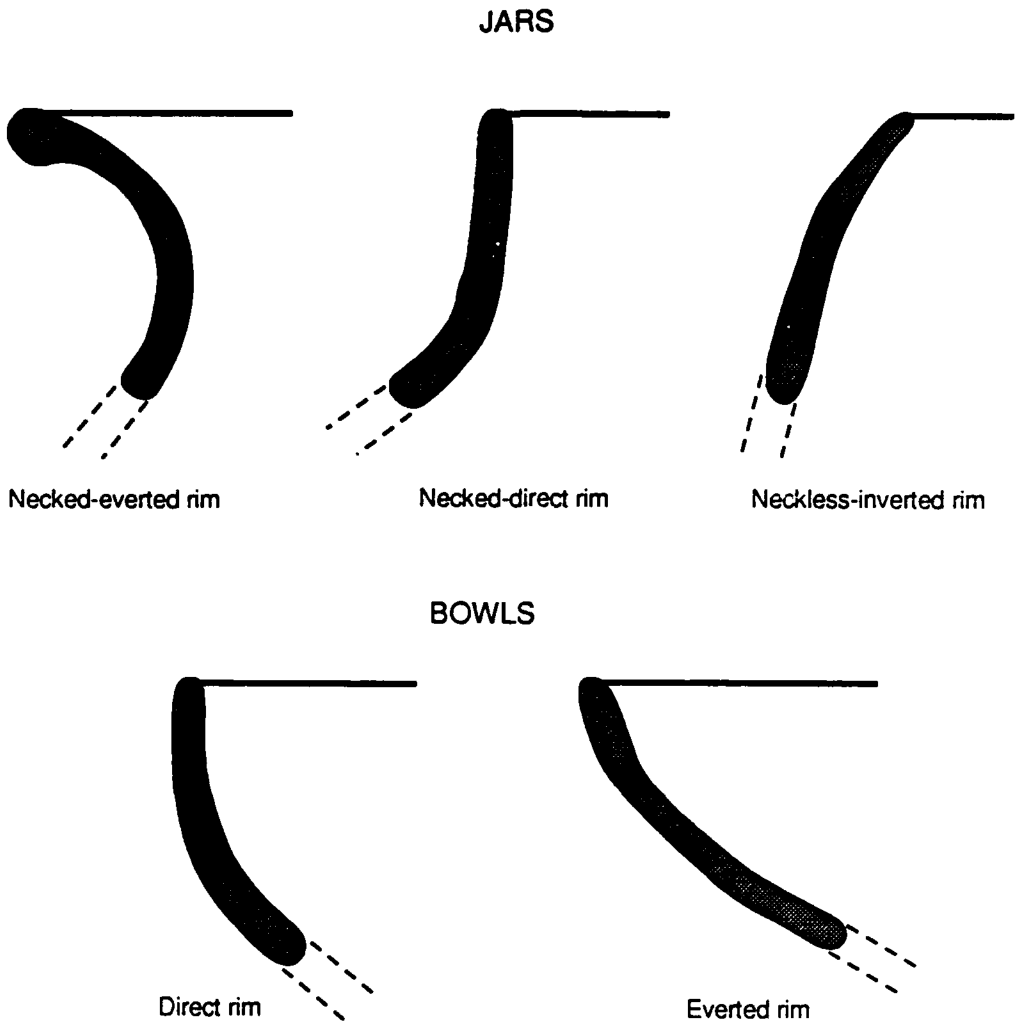


Figure 13.2. El Paso Brownware vessel forms

After these general relationships were established, presence/absence criteria among a number of key ceramic groups were utilized to assign phase designations to the Border Star 85 sites and their ceramic assemblages that contain El Paso Brownware rims. The following ceramic type groupings were used in assigning phase designations:

1) Mesilla phase: El Paso Brown, San Francisco Red, Mogollon R/B, Three Circle R/W, Mimbres B/W (Styles I–III)

2) Doña Ana phase: El Paso Brown, Mimbres B/W (Styles II and III), El Paso Bichrome, El Paso Polychrome, Chupadero B/W, Magdelena B/W (carbon paint), red-on-terracotta types

3) El Paso phase: Doña Ana types minus Mimbres B/W plus Playas Red, Lincoln B/R, Mexican polychromes, White Mountain Redwares, Agua Fria G/R, Tucson Polychrome

It should be remembered that these criteria take into account neither type frequency nor the possibility of sites being occupied in more than one phase. It should also be noted that early and late variants of both El Paso Plain Brown and El Paso Polychrome were not used in the assignment of phases. Doing so would invalidate this analysis for these variants are defined by rim form differences. Given the relative rarity of most diagnostic types, and the low sampling fraction of the TRU samples, it is likely that a substantial number of the assemblages are placed in inappropriate phases, which is especially true of Transitional sites, where the presence or absence of Mimbres B/W often determines whether it is placed in the Doña Ana or El Paso phases. Very large sites containing diagnostic ceramic types indicative of occupation during all three of the Formative period phases (multicomponent sites) were excluded from analyses concerned with phase-specific RSI patterning.

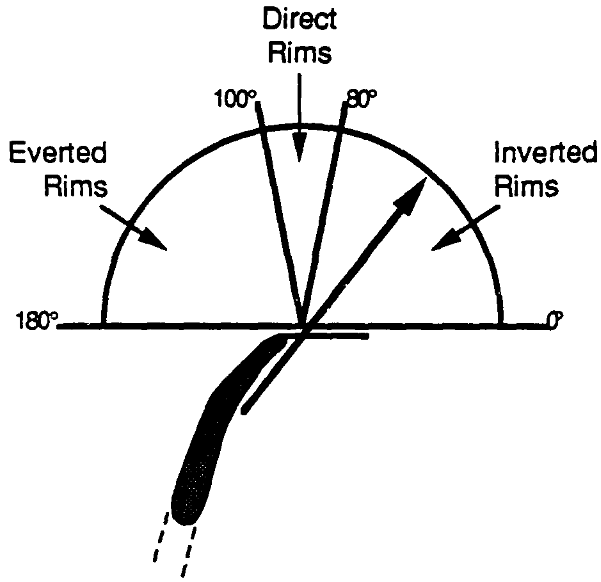


Figure 13.3. Rim eversion measurement

Analysis Results

Ceramic Type and Vessel Form Patterning in the RSI

The first step in the analysis was to investigate the relationship between ceramic type and RSI and how El Paso Bichrome should be treated analytically. As previously noted, field identification of this type is error-prone due to weathering of its fugitive red paint. An inspection of RSI box plots for the three El Paso Brownware types recovered from the Border Star 85 Surveys (Figure 13.4) suggests that Whalen's decision to lump bichrome with plain brownwares would probably introduce unnecessary variability into his "late" brownware sample if RSI had been measured. The distributions of RSI values for El Paso Brown and El Paso Bichrome in Figure 13.4 exhibit very little overlap in their respective interquartile ranges (IQR), and combining these two types is likely to yield a *muddled* analytical category. On the other hand, Carmichael's strategy of eliminating bichrome sherds from his interphase comparisons seems to result in less robust statistics in that his sample sizes could be significantly higher if bichrome had been lumped with polychrome rather than dropped. Mean RSI values for the Border Star 85 sample suggest that the lumping of bichrome and polychrome types would have considerably less effect on the central tendencies of RSI than it would if bichrome sherds were lumped with the El Paso Plain Brownwares.

Although there is considerable overlap in the distributions, differences between the mean RSI values for all three types are found to be statistically significant at the .05 confidence level (CL) (Table 13.2). The difference between bichrome and polychrome types is not as pronounced, however, as the plain brown-bichrome or plain brown-polychrome comparisons, and their respective variances—as measured by standard deviations (Table 13.2) or interquartile ranges (IQR; Figure 13.4)—are very close to being equal. Despite the statistically significant difference between the two painted brownware types, it is believed that combining these types would have only a minor effect on mean RSI values. Much of the variability in bichrome RSI values may be due to variation in vessel form frequency because there is a significantly higher proportion of bowls vessel forms within the painted El Paso brownwaes (Table 13.1), and bowls, as shown below, have significantly thinner rims than jars. El Paso Bichrome sherds are therefore lumped with El Paso Polychrome sherds for all RSI analyses outlined below.

Statistically significant differences in RSI were found between generic vessel forms, but only for the painted El Paso Brownwares. As the first comparison in Table 13.3 illustrates, mean RSI values for El Paso Plain Brown bowl and jar rims are almost identical with a difference in the

Table 13.2. Comparison of Rim Sherd Index (RSI) distributions among El Paso Brownware ceramic groups

Ceramic Group	N	Mean RSI	s
El Paso Brown	267	0.878	0.176
El Paso Bichrome	55	1.188	0.334
El Paso Polychrome	111	1.314	0.324

t-test Comparison Sample 1	Sample 2	Difference in Means	$\lvert t \rvert$*	*df*	$p > \lvert t \rvert$	Significant**
Brown	Bichrome	0.310	6.69 –	60.3	0.0001	Yes
Brown	Polychrome	0.436	13.38 –	137.8	0.0001	Yes
Polychrome	Bichrome	0.126	2.33 =	164.0	0.0208	Yes

* – variances unequal; = variances equal (based on F-tests)
**.05 confidence level

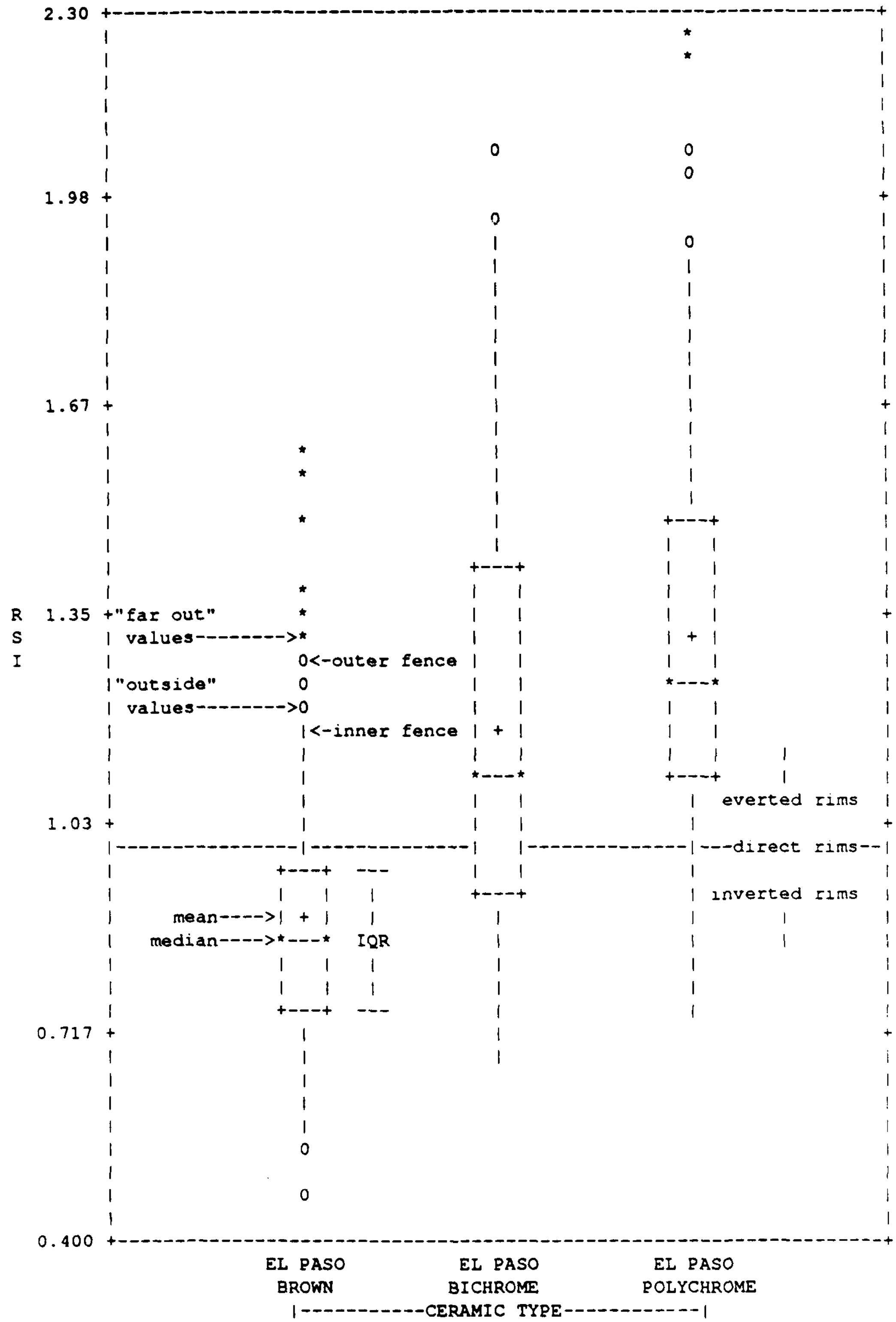


Figure 13.4. Box plots of Rim Sherd Index (RSI) data by ceramic type

Table 13.3. Comparison of Rim Sherd Index (RSI) distributions among El Paso Brownware ceramic groups and vessel forms

Ceramic Group	Vessel Form	N	Mean	s
El Paso Brown	Bowls	33	0.868	0.172
El Paso Brown	Jars	199	0.874	0.178
El Paso Bi/Polychrome	Bowls	38	1.127	0.264
El Paso Bi/Polychrome	Jars	123	1.326	0.340

t-test Comparison Sample 1–Sample 2	Difference in Means	$\lvert t \rvert$*	*df*	$p > \lvert t \rvert$	Significant**
Jars–Bowls					
(a) Brown	0.006	0.17 =	230.0	0.8619	No
(b) Bi/Polychrome	0.199	3.78 –	78.4	0.0003	Yes
El Paso Brown-Polychrome					
(a) Bowls	0.259	4.82 =	69.0	0.0157	Yes
(b) Jars	0.452	13.65 –	164.0	0.0001	Yes

* – variances unequal; = variances equal (based on F-tests)
**.05 confidence level

group means of only 0.006. In contrast, the painted brownware bowls and jar groups are quite different in RSI, although their ranges overlap a considerable amount. The *t*-test results in Table 13.3 indicate that the difference in mean RSI values for painted bowls vs painted jars is statistically significant at the .05 CL or better, while the results for the El Paso Plain Brown groups are far from this level of significance. The second comparison in Table 13.3 illustrates that when vessel form is held constant, differences between painted and plain El Paso Brownware RSI means are also statistically significant at the .05 CL or better. This pattern is especially pronounced in the case of jars, with a difference in ceramic group means of 0.452 RSI.

We turn now to the relationship between rim form or eversion and RSI. Figure 13.5 illustrates a well-known pattern in El Paso Brownware rims—rims get thicker as they become more everted. For El Paso Plain Brown sherds, the increases in RSI with increasing eversion are marginally significant (at the .05 CL) only for the inverted vs direct rim form comparison (comparison #1; Table 13.4).In contrast, comparisons among all rim form means for the painted brownwares were statistically significant at the .05 CL or better (comparison #2; Table 13.4). Comparisons between plain versus painted types within rim form categories were equally significant.

The previous relationship, however, holds only for jars. In fact, bowl rims tend to get thinner with increasing eversion—the trend is most pronounced for El Paso Polychrome rims (Figure 13.6).

Five basic vessel types are possible when generic vessel form (bowl versus jar) and rim form (inverted, direct, and everted) are combined (Figure 13.3). Bowls can have either direct or everted rims with the latter form representing shallower vessels if rim diameter is held constant. Everted rim vessels also have smaller volumes. Jars with inverted rims are probably neckless forms, such as seed jars or tecomates, while those with direct or everted rims constitute necked jar forms. Differences in rim thickness among all five vessel forms are not statistically significant, but *t*-tests suggest three groupings based on vessel form means (Table 13.5). Group A contains only one vessel form—everted, necked jars—and has a mean RSI of 1.45. Direct rimmed bowls and necked jar forms with mean RSI values just above 1.0 make up Group B. Group C vessel forms included everted bowls and neckless jars with inverted rims, which have mean RSI values of 0.92 and 0.86, respectively.

No changes are evident in the vessel form groups when RSI means for the painted types are treated separately (Table 13.5). RSI means for the El Paso Plain Brown rims fall into two groups, however. Only the necked-everted jar forms are isolated by the *t*-tests on the basis of mean RSI; all other vessel forms can be lumped into the second RSI group.

Temporal Patterning in RSI Values

In practice, controlling for vessel form has less effect than might be expected on RSI means from different temporal phases. No differences in the phase means were found to be statistically significant (at the .05 CL) when statistics from a sample of jar rim sherds were compared with those from the sample of all vessels. Although small sample sizes preclude using the more fine-grained vessel form classes for valid statistical comparisons, patterning in both the mean RSI values and frequencies for the five vessel classes

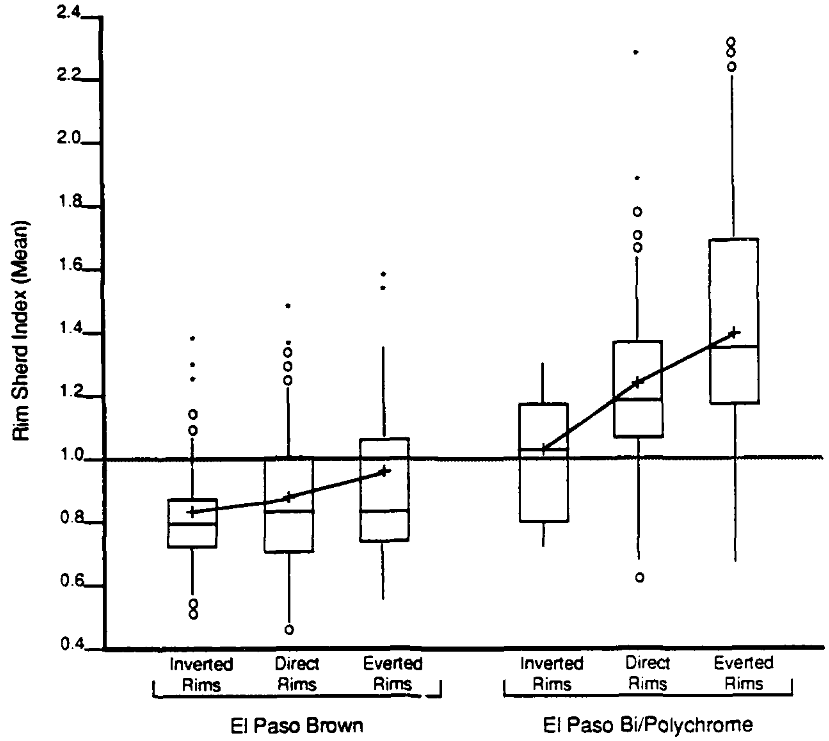


Figure 13.5. Box plots of Rim Sherd Index (RSI) means: Ceramic group by rim form

Table 13.4. Comparison of Rim Sherd Index (RSI) distributions among El Paso Brownware ceramic groups and rim form categories

Ceramic Group	Rim Form	N	Mean	s
El Paso Brown	Inverted	128	0.843	0.141
El Paso Brown	Direct	64	0.898	0.100
El Paso Brown	Everted	15	0.980	0.290
El Paso Bi/Polychrome	Inverted	11	1.022	0.167
El Paso Bi/Polychrome	Direct	83	1.207	0.269
El Paso Bi/Polychrome	Everted	66	1.418	0.373

t-test Comparison Sample 1–Sample 2	Difference in Means	$\lvert t \rvert$*	*df*	$p > \lvert t \rvert$	Significant**
El Paso Brown					
(a) Inverted-Direct	0.055	1.96 –	95.8	0.0520	Yes
(b) Inverted-Everted	0.137	1.80 –	14.8	0.0924	No
(c) Direct-Everted	0.082	1.04 –	17.2	0.3130	No
El Paso Bi/Polychrome					
(a) Inverted-Direct	0.185	3.16 –	17.8	0.0055	Yes
(b) Inverted-Everted	0.396	5.80 –	30.3	0.0003	Yes
(c) Direct-Everted	0.211	3.87 –	114.4	0.0002	Yes

* – variances unequal (based on F-tests)
**.05 confidence level

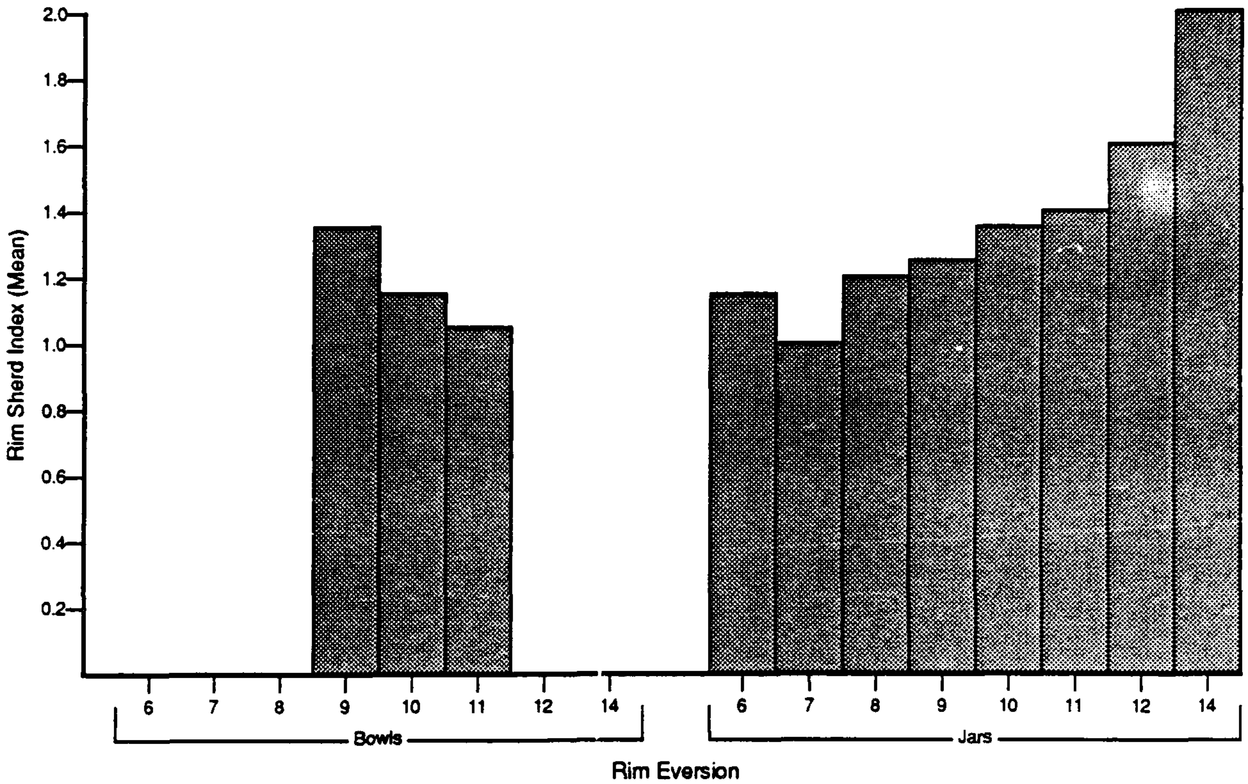


Figure 13.6. Bar chart of Rim Sherd Index (RSI) means: El Paso Polychrome rim sherds

illustrate how chronological placement using RSI can be biased by vessel form (Table 13.6).

Variability in RSI across these five vessel forms is highest for the painted types in Doña Ana and El Paso phase assemblages and lowest for El Paso Plain Brown in Mesilla and Doña Ana phase assemblages. This suggests that controlling for vessel form is less important in computing mean RSI values for Mesilla phase sites than it is for Doña Ana and El Paso phase assemblages. In the latter case, however, the computation of RSI means appears to be very sensitive to variation in vessel form.

Table 13.5. El Paso Brownware vessel form groups based on t-tests of RSI Means*

Grouping	Mean RSI	N	Vessel Form
A	1.4543	56	Necked Jars—Everted Rim
B	1.0686	60	Necked Jars—Direct Rim
	1.0545	46	Bowls—Direct Rim
C	0.9165	14	Bowls—Everted Rim
	0.8567	105	Neckless Jars—Inverted Rim

*alpha = 0.05 $df = 272$ MSE = 0.0528395
Critical value of $t = 1.96872$
Least significant difference = 0.106022
Harmonic mean of cell sizes N = 36.4391
Means in the same grouping are not significantly different.

In comparing the Border Star 85 results with those published in Carmichael's (1983) study, several differences in phase specific RSI statistics became apparent. Table 13.7 documents two significant differences. First, El Paso Polychrome (BiPolychrome in the Border Star 85 sample) RSI means differ for both the Doña Ana and El Paso phases—the Border Star 85 sample means are lower in each case. Second, El Paso Brown RSI means for the Mesilla phase diverge considerably, with the Border Star 85 sample means being higher.

It seems likely that the former difference is to a large extent a function of the typological criteria used in defining the El Paso phase by Carmichael. Both Whalen and Carmichael seem to rely on a model of temporally abrupt replacement of El Paso Brown by El Paso Polychrome in the El Paso phase, while the position has been taken here that the replacement was more gradual and that unpainted wares are expected to occur in decreasing frequencies during the El Paso phase. This variation seems to have resulted in significant differences in RSI means for the El Paso phase noted in Table 13.7. In an effort to adjust for the differences in phase definition, the Border Star 85 El Paso phase sample of painted brownwares was partitioned into two subsamples for comparison with Carmichael's RSI statistics (1983:84). Those Border Star 85

Table 13.6. Rim Sherd Index: Temporal phase statistics by ceramic group and vessel form

Phase	Group	Vessel Form*	N	Mean RSI	s	Min	Max
Mesilla	Plain	DIR BOWL	1	0.76	.	0.76	0.76
		EVT BOWL	3	0.81	0.021	0.78	0.82
		INV NLJAR	30	0.84	0.124	0.61	1.22
		DIR NJAR	5	0.74	0.172	0.46	0.91
		EVT NJAR	1	1.04	.	1.04	1.04
Doña Ana	Plain	DIR BOWL	17	0.90	0.218	0.62	1.37
		EVT BOWL	3	0.88	0.112	0.78	1.00
		INV NLJAR	58	0.85	0.147	0.58	1.38
		DIR NJAR	14	0.89	0.214	0.70	1.50
		EVT NJAR	3	0.79	0.171	0.62	0.96
Doña Ana	Painted	DIR BOWL	5	0.93	0.116	0.81	1.05
		EVT BOWL	1	0.74	.	0.74	0.74
		INV NLJAR	4	0.85	0.030	0.81	0.88
		DIR NJAR	4	0.83	0.076	0.78	0.94
		EVT NJAR	3	1.70	0.414	1.24	2.04
El Paso	Plain	DIR BOWL	1	0.91	.	0.91	0.91
		INV NLJAR	5	0.88	0.042	0.84	0.95
		DIR NJAR	7	0.93	0.111	0.79	1.09
		EVT NJAR	2	1.58	0.007	1.58	1.58
El Paso	Painted	DIR BOWL	13	1.17	0.257	0.68	1.67
		EVT BOWL	3	0.96	0.041	0.91	0.98
		INV NLJAR	1	0.92	.	0.92	0.92
		DIR NJAR	18	1.27	0.190	1.00	1.80
		EVT NJAR	34	1.50	0.311	1.04	2.26

*DIR BOWL = Bowl with Direct Rim
EVT BOWL = Bowl with Everted Rim
INV NLJAR = Neckless Jar with Inverted Rim
DIR NJAR = Necked Jar with Direct Rim
EVT NJAR = Necked Jar with Everted Rim

Table 13.7. Comparison of RSI data: Carmichael vs Border Star 85

		Carmichael (Site Mean RSI)					Borderstar-85 (Site Mean RSI)					*t*-Tests					
					(95%)					(95%)			(Var =)		(Var ≠)		
Group	Phase	N	Mean	s	LCL	UCL	N	Mean	s	LCL	UCL	Diff	*t*	*df*	*t*	*df*	p (*t*)
Brown	Mesilla	70	0.77	0.134	0.74	0.80	32	0.84	0.131	0.79	0.89	0.07	2.44[1]	100	2.45	63	.01 < p < .02
	Doña Ana	39	0.92	0.126	0.88	0.96	10	0.91	0.078	0.86	0.96	0.01	0.23	47	0.30[2]	24	p > .20
	El Paso						14	1.01	0.221	0.89	1.13						
Bi Poly	Doña Ana	34	1.06	0.164	1.00	1.12	6	0.93	0.181	0.79	1.07	-0.13	1.72[2]	38	1.51	7	.05 < p < .10
	El Paso	53	1.37	0.245	1.31	1.43	30	1.24	0.259	1.15	1.33	-0.13	2.25[1]	81	2.21	59	.02 < p < .05
Comparison #1[3]		53	1.37	0.245	1.31	1.43	23	1.28	0.227	1.19	1.37	-0.09	1.48[2]	74	1.52	46	.10 < p < .20
Comparison #2[4]		34	1.06	0.164	1.00	1.12	7	1.07	0.310	0.84	1.30	0.01	0.12	39	0.08[2]	7	p > .20

H_0: Mean RSI (Borderstar-85) − Mean RSI (Carmichael) = 0
Confidence Level = 0.05 for a two-tailed test
[1]Reject H_0 (i.e., Mean RSI significantly different)
[2]Cannot reject H_0 (i.e., Mean RSI *not* significantly different)
[3]#1: Comparison of Carmichael El Paso (Bi/Poly) with "pure" BS-85 El Paso (Bi/Poly) sites (i.e., no El Paso Brown present in assemblage)
[4]#2: Comparison of Carmichael Doña Ana (Bi/Poly) with "mixed" BS-85 El Paso (Bi/Poly) sites (i.e., El Paso Brown present in assemblage)

sites with no plain brownware associated with painted types (i.e., "pure" assemblages) were compared with Carmichael's El Paso phase sample (comparison #1; Table 13.7). In contrast to the earlier *t*-test results for this phase, no significant difference in mean RSI is evident. A similar comparison (comparison #2; Table 13.7) of the "mixed" Border Star 85 El Paso phase assemblages with Carmichael's Doña Ana phase sample had identical results. These two comparisons seem to indicate that differences in phase definition are responsible for the initial lack of agreement between the two samples.

Another factor relates to sampling problems in surface survey. It involves sites that are structurally complex due to multiple or long-term occupations. Given the generally poor resolution of the Border Star 85 survey in defining site boundaries and in documenting the existence of multicomponent sites, it is not surprising that the Border Star 85 Mesilla phase RSI values are greater than Carmichael's. Most likely, these values are biased by the inclusion of large Mesilla phase sites with long occupational histories and/or by Doña Ana or later sites that were misidentified as Mesilla during Phase I survey because rare diagnostic ceramic types were missed by the Transect Recording Units. Plain brownware rims from the later components are expected to be thicker than those of earlier components, and thus *average* RSI values would be expected to be intermediate. This appears to be the case in Table 13.7, where the Border Star 85 Mesilla phase RSI mean is almost exactly halfway between Carmichael's Mesilla and Doña Ana phase means.

On a more specific level, this pattern of El Paso Brown RSI values can be seen in assemblage data from LA 62125. Based on radiocarbon and ceramic evidence (presented in Chapter 8) this site appears to have been used throughout the entire Mesilla phase and perhaps into the Doña Ana phase. The stem/leaf chart and box plot in Figure 13.7

```
STEM LEAF                          #     BOXPLOT
  15 0                             1        0
  14
  14
  13 7                             1        |
  13                                        |
  12                                        |
  12                                        |
  11                                        |
  11 2                             1        |
  10 68                            2        |
  10 003                           3        |
   9 567788                        6     +-----+
   9 00124                         5     |     |
   8 5568                          4     |  +  |
   8 0334                          4     *-----*
   7 89                            2     |     |
   7 00133444                      8     +-----+
   6 66778888                      8        |
   6 22                            2        |
     ----+----+----+----+
     MULTIPLY STEM.LEAF BY 10**-01
```

Figure 13.7. LA 62125 El Paso Brown Rim Sherd Index (RSI) distribution

show a clear bimodal distribution in RSI values, with a major peak at 0.70 RSI and a minor one at 0.95—figures that are very close to Carmichael's Mesilla and Doña Ana phase averages. These peaks are not reflected in the mean RSI for the site of 0.857 ($n=47$; $s=0.183$), however, nor are they apparent in the median value of 0.842. It is quite probable that this site is not unique in the Border Star 85 sample.

One significant pattern evident in Border Star 85 data has several implications. As can be seen in Figure 13.8, the frequency of inverted neckless jars of El Paso Brown, which have consistently small RSI values throughout all phases, decreases drastically in the El Paso Phase. This form and type is replaced by the necked jar vessel forms of both El Paso Brown and Bi/Polychrome, which have consistently higher RSI values. Thus, it appears to be just as much the *replacement* of neckless jar forms with necked ones as it is the increase in rim thickness per se that affects RSI phase means, if one ignores ceramic type groupings. When vessel form is not controlled for, RSI statistics may be measuring changes in vessel form frequencies rather than stylistic change in rim shape. If one assumes a gradual replacement through time of El Paso Brown with the painted brownwares, as Lehmer (1948) suggests, this pattern is significant from a functional standpoint as well.

What Are We Measuring?

As the above discussion shows, the RSI does appear to be a chronologically sensitive indicator when certain controls, such as vessel form, are considered. The identification of temporally significant variables and the explanation of why these variables change through time, however, are two very different problems. In the remainder of this paper we will explore the correlation of the changes in the RSI with other aspects of vessel morphology and the implications of both for changes in vessel use.

Two formal variables correlated with increases in the RSI are important for the discussion of changes in vessel form: relative constriction of the rim area and vessel size. As noted above, the rim eversion measure has allowed the differentiation of five different formal classes among the El Paso Brownware sherds (three of jars and two of bowls). These classes have been shown to have significantly different RSI values when placed into three groups. In considering the jars, the most frequent form present, the general trend noted previously in the literature is evident: there is a trend from neckless jars to necked jars with direct rims to jars with everted rims.

The presence/absence of a neck is an important variable not only for describing differences in vessel shape but also for understanding the potential range of vessel uses. An increase in the constriction of vessels may be due to the desire to increase two general vessel properties: the ability to keep contents from spilling or to change the form of vessel closure. Simple restricted vessels, such as the inverted jar form, are not useful for the containment of liquids. Effective closure of vessels with constricted necks is most easily accomplished with a lid; however, it is also possible that they were not constructed to be closed at all.

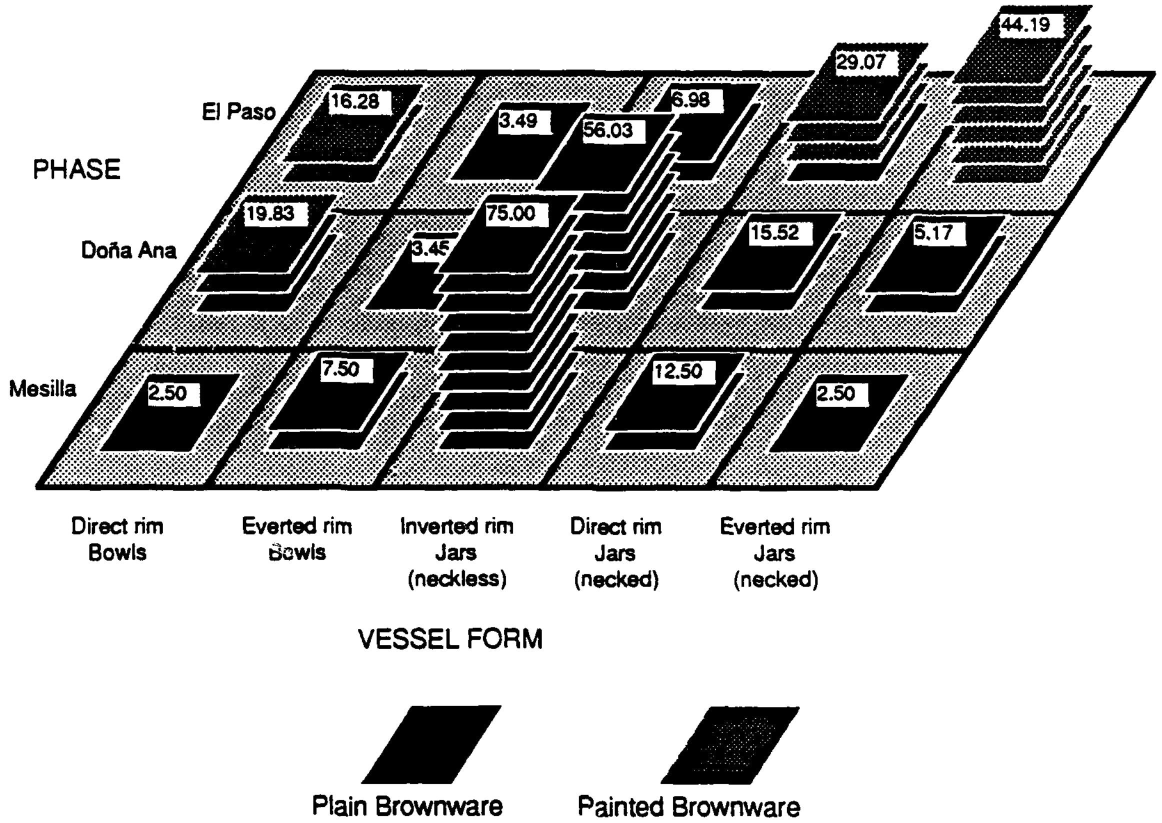


Figure 13.8. Border Star 85 El Paso Brownware rims: Percentage block chart

Both the jars with direct rims and the jars with everted rims have more restriction of the neck area. Either of these two forms will provide "containment security" (Braun 1980). This is generally more important for liquids, although the more secure containment of small nonliquid items would also be enhanced. Closure of these vessels is also considerably improved. The neck provides a convenient means for tying on closing materials, placing lids on top, or for inserting stoppers; all are closing techniques that have been documented elsewhere in the Southwest. Published photographs of El Paso Brownware (e.g., Stallings 1931) show that the everted rim form occurs with globular shapes, a characteristic well suited to extensive boiling of contents (e.g., Braun 1983; Hard 1983a).

Measures of overall vessel size, such as maximum diameter, height, or volume, are difficult to do without a comparative collection of whole vessels. Rim diameter does provide a general indication of changes in overall vessel size, and it is usually positively correlated with increases in such measures as volume (Fitting and Halsey 1966; Nelson 1985). Although rim diameter was not recorded for the Border Star 85 rim sherds, data are available for El Paso Brownware from the BLM Santa Teresa Land Exchange Survey west of El Paso (Camilli 1986). Figure 13.9 shows a bar graph of rim eversion intervals grouped in the same way as they were for the Border Star 85 data in order to look at differences among the three rim forms. There is a clear decrease in rim diameters between inverted and direct and a correlative increase from direct to everted. The *t*-tests show that the differences in rim diameter between inverted and direct forms are not significant, but differences between direct and everted rims are significant at the .01 CL. There is no statistically significant difference in the rim diameters between inverted and everted rims.

Also important in the histogram of rim form by orifice diameter (Figure 13.9) are the wider ranges of the diameter measurements for both the simple restricted (i.e., neckless) vessels and those with everted necks. The wide ranges suggest multiple functions within each of these categories. The largest vessels in each category (greater than 30 cm in diameter) are among the largest ceramic vessels made in the Southwest (cf. Lerner 1984:Table 31; Nelson 1985:Fig. 12.3; Toll and McKenna 1983:Table 6–9). It seems likely that the largest vessels were not moved very frequently, probably serving as "site furniture" (Binford 1978). Based on size alone, it is probable that these large vessels were used for cooking on special occasions, a pattern ethnographically documented by Nelson (1981, 1985), and/or as semipermanent storage facilities.

In terms of temporal differences in assemblages, here treated

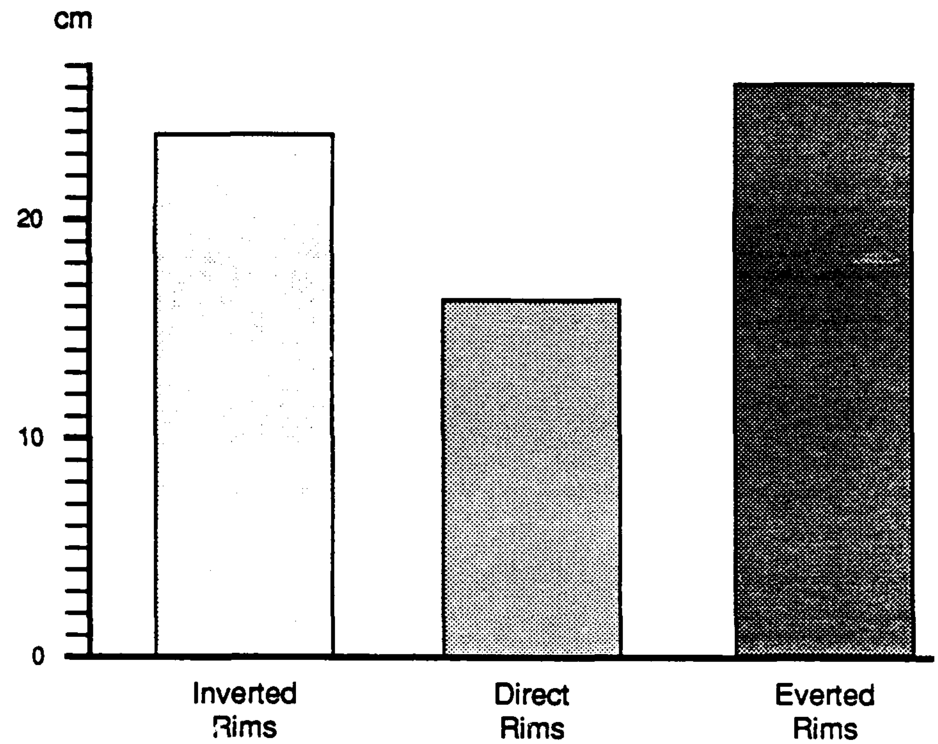


Figure 13.9. El Paso Brownware rims: Mean rim diameter (Santa Teresa Land Exchange data)

as the composite of vessel forms and types within a single phase, we see two conclusions significant for this discussion of changes in vessel use. First, the rapid replacement model of El Paso Plain Brown with El Paso Polychrome may not be appropriate. Although mixed assemblages are undoubtedly present, it is apparent that El Paso Plain Brown was made and used during at least the early portion of the El Paso phase. Second, in most other areas of the Southwest, painted types were gradually added to the plainware assemblages, indicating a greater functional specificity in the role of different ceramic classes. While decreases in the frequencies of plain brown are evident, it should not be assumed that they were replaced as rapidly as many discussions of the ceramic sequence in the El Paso area have suggested.

Given the differences in vessel forms identified above, we are now in a position to offer some interpretations of the changes in assemblage composition outlined in Table 13.6. Rim eversion changes from the inverted forms of the Mesilla phase to the direct forms of the Doña Ana phase suggest that the use of the El Paso Brownware vessels may have shifted through time from storage of materials that did not require much containment security (i.e., probably not liquids) either to liquids or other materials that needed to be sealed more tightly or to cooking rather than storage requirements. The large sizes of the neckless or inverted forms suggest that they probably were not moved very frequently and may have served as "site furniture" or for the caching of goods. The range of orifice diameters is large within the neckless forms, however, and it is likely that these jars were used for more than one function, perhaps for limited cooking as well as storage.

The inverted or neckless forms would not be well suited to long-term boiling because the relatively small orifice diameters would inhibit stirring of contents, an activity that is particularly necessary when starchy foods are being prepared, such as corn. In addition, the absence of a neck leaves little resistance to boil-overs. Sooting on the exteriors of El Paso Plain Brown neckless vessels has been documented in excavation assemblages (Anyon 1985), indicating that vessels with this rim form were probably used for cooking in at least some cases. It might be suggested that high temperatures were not used and that techniques generally involved stone boiling rather than direct placement on a hearth area, or cooking with relatively low heat. Since 75 percent of the rim sherds placed in the Mesilla phase are from inverted neckless vessels, it is further suggested that the range of functions of ceramic containers was limited during this phase. In fact, computation of Shannon-Weaver diversity indices for the three phases shows an increase in ceramic vessel diversity through time (Figure 13.10).

Vessels with direct rims, found most commonly in the Doña Ana and El Paso phases, have smaller mean rim diameters and would be efficient for the processing, storage, and/or transport of liquids. Only the largest of these vessels would be suitable for cooking, but the relatively high necks evident on the few published profiles of whole vessels (Smiley 1977:Fig. II.26; Whalen 1981a:Fig. 3e) suggest that stir-

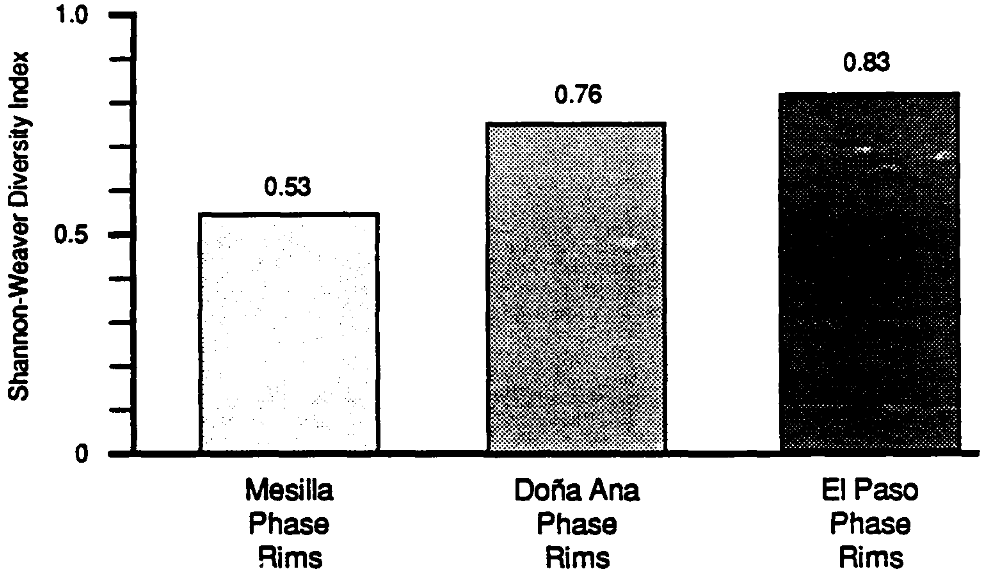


Figure 13.10. El Paso Brownware rims: Vessel form diversity

ring of contents may have been difficult even with the larger rim diameters.

The wide range of variability in the published profiles of whole vessels with direct rims is correlated to some extent with surface treatment variability. Plain brownware vessels with direct rims (such as those illustrated in Whalen 1981a:Fig. 3e), have small maximum body diameters, while El Paso Polychrome vessels with this neck shape (e.g., Smiley 1977:Fig. II.26) have large maximum diameters. Vessels with direct rims and small maximum body diameters are very similar to the cactus-fruit processing vessels ethnographically documented among the Papago (Fontana et al. 1962:Fig. 82), while direct rims and large body diameters are more similar to the water storage and transport vessels found among a variety of Southwestern ethnographic groups (e.g., Stevenson 1883). The continued use of jars with direct necks during the El Paso phase is probably due to the use of these vessels for liquid storage and/or transport.

In addition to having large rim diameters, jars with everted rims also have the widest range of these diameters. As with the vessels with inverted rims, it seems likely that multiple functions may be represented within this general form. The very largest of these, with rim diameters in excess of 40 cm, were probably not moved very frequently and were most likely used for storage. Smith (1985) has shown that for storage vessels the larger the orifice size, the shorter the duration of storage. Although we are monitoring changes in rim and not orifice diameter, it is probably true that the larger rim diameters also indicate relatively large orifice diameters and therefore probably indicate vessels used for relatively short-term storage.

The smaller everted rim vessels may have been used for cooking, although this particular shape is quite different from that recorded in most ethnographic descriptions of cooking pots. Rarely are such vessels decorated (Mills 1984b:Table 8.1), but this shape in El Paso Brownware frequently is. The decoration primarily occurs on the neck and upper body and would be relatively protected from sooting by cooking fires; therefore, the presence of this type of decoration may even argue for the use of stone boiling as the most common cooking technique rather than direct placement on a hearth.

The shift to cooking vessels with everted rims and globular bodies has been correlated with lengthy boiling techniques, and, particularly, with the boiling of starchy seeds, such as corn and beans (Braun 1983; Hard 1983a; Linton 1944; Stiger n.d.). Unfortunately, ethnobotanical information on the relative role of starchy seeds in the prehistoric subsistence systems of the El Paso area is limited (cf. Ford 1977; O'Laughlin 1977a; Wetterstrom 1978). O'Laughlin's summary of subsistence remains from the Fort Bliss area suggests that after AD 1000 a new variety of Pueblo corn became widespread, but the extent to which this variety was adopted is not well known. Thus, while it seems likely that assemblage changes to increasingly more everted jars during the El Paso phase are correlated with changes in the types of food being cooked and/or the proportions of these foods in the diet, independent data are not presently available.

Summary

We are now in a position to summarize the major changes evident in the size and shape of El Paso Brownware vessels that may be correlated with changes in the use of these vessels. First, in terms of changes in the size of vessels, large vessels appear to have their greatest use during two

phases, Late Mesilla and El Paso, while the Doña Ana phase assemblages have significantly smaller vessels. We have suggested that the larger vessels may indicate a greater use of ceramics for storage and further that this storage was probably of a shorter duration. The very large size of some of these vessels suggests that they were not frequently moved and probably served as permanent facilities at the sites where they were found. The use of these ceramics as permanent facilities, however, does not necessarily imply the use of the sites on a permanent, year-round basis. In fact, it may suggest the opposite. If year-round occupation at these sites was practiced, it might be expected that nonceramic containers, such as pits or architectural features, would have been used.

Second, the distinct changes in the shape of El Paso Brownware vessels also have functional implications. While inverted, neckless vessels are most prevalent during the Late Mesilla phase, necked vessels predominate within most later assemblages. The change from neckless to necked vessels may have two functional implications. First, it suggests an increase in the security of contents, both liquid and solid. This may indicate greater use of ceramics for dry storage, as well as for liquid storage and transport. Second, necked forms are more appropriate for longer duration cooking, such as food boiling, particularly of starchy foods, and may be indicative of a change in meal preparation techniques, if not in diet as well.

Finally, differences in the RSI values of El Paso Brownware rim sherds have been shown to be chronologically significant. These RSI values are also correlated with changes in vessel shape and size. Implications for changes in the role of ceramics in El Paso Brownware assemblages have been offered as a basis for further research, although larger sample sizes and the testing of these functional interpretations with subsurface collections are needed in an effort to ascertain their validity. These interpretations are offered here, however, in an effort to understand why chronologically significant changes in RSI values of El Paso Brownwares took place. An attempt has been made to place these changes in a more meaningful framework for behavioral interpretations.

Chapter 14

PETROGRAPHIC STUDIES

Dale Rugge

This chapter presents the results of the petrographic analyses performed on a sample of Classic Mimbres Black-on-white ceramics from three areas within the Tularosa Basin and from the Mimbres Valley. The analysis was performed in order to clarify the issues raised in Chapter 12 concerning the Doña Ana phase and the frequent co-occurrence therein of Classic (or Style III) Mimbres Black-on-white, dated firmly to AD 1100–1150 in the Mimbres Valley (Anyon 1980), and the locally produced (i.e., in the Jornada region) El Paso Polychrome with a beginning date of about AD 1150 (Whalen 1981a). This study will also seek to clarify the mechanism(s) responsible for the occurrence of Mimbres Black-on-white in the Tularosa Basin.

In order to account for the apparent contemporaneity of these two types, some adjustment to these dates is necessary. Either the cutoff date for Mimbres Black-on-white should be extended to at least AD 1200 in the Jornada Mogollon region or the El Paso Polychrome beginning dates should be pushed back to AD 1100 or earlier (or both).

There are several interpretations of centers of production based on the idea that Mimbres Style III and El Paso Polychrome were produced contemporaneously. Carmichael (1983) has speculated that Mimbres series ceramics continued to be produced in the Jornada Mogollon region after the depopulation of the Mimbres Valley; he includes Mimbres Black-on-white in his grouping of "local intrusives" along with Three Rivers Red-on-terracotta, Chupadero Black-on-white, and Playas Red (Carmichael 1983:68–69). Contrary to this view is the one espoused by LeBlanc and Whalen (1980), which suggests that Mimbres ceramics were traded into the relatively lightly populated Jornada area from the core Mimbres area.

Petrographic analysis of ceramics is well suited to an examination of these competing interpretations. If it can be demonstrated that Mimbres ceramics occurring in the Tularosa Basin were produced in the Mimbres Valley, we will then know that the same dating sequence is applicable to both areas. Similarly, if it can be demonstrated that Mimbres ceramics were produced in the Jornada region, then the application in the Tularosa Basin of the dating sequence developed for the Mimbres Valley must be considered tentative.

Previous Work

Little petrographic work has been done on ceramics from the Tularosa Basin, and until recently no research results have been available concerning Mimbres series ceramics recovered in the Tularosa Basin. In 1985, however, two petrographic studies were completed on Mimbres series ceramics from the Tularosa Basin. The first described a sample of 12 Mimbres sherds from the Fairchild site South of Alamogordo (Rugge 1985a), and the second consisted of a sample of 9 Mimbres sherds from the Ft. Bliss military reservation (Rugge 1985b). The current study thus represents the third performed by this author on Mimbres series ceramics recovered in various parts of the Tularosa Basin.

In addition to data from the above studies, information from one earlier petrographic study of ceramics from the Tularosa Basin is available, although the study did not include a sample of Mimbres ceramics (Rugge 1978). Petrographic data on Mimbres ceramics from the Mimbres Valley are available (Rugge 1976), but quantitative comparison with the current data set is not possible. Consequently, 15 of the samples previously analyzed from the Mimbres Valley were borrowed from the Maxwell Museum of Anthropology, University of New Mexico, and were reanalyzed to facilitate quantitative comparisons with the data collected in the current study. The result has been that a quantitative data set for 64 Mimbres series sherds has been amassed: 28 from the present study, 15 from the Mimbres Valley, 12 from the Fairchild site, and 9 from the Ft. Bliss military reservation. In comparison with petrographic information available for other regions, this amount of data may seem quite impressive at first glance. One need only be reminded of the tremendous geographic gaps existing in the data base, however, to realize that this study marks only the beginning of what must ultimately be done to understand the production and distribution of Mimbres series ceramics.

The Sample

All Mimbres series ceramics collected on the Border Star 85 survey were identified as to type (Style I, Style II, and Style III). All sherds positively assignable to one of these three types (Chapter 12) were selected for analysis. In addition, those that were indeterminately assignable to either Style II or Style III were also included in the sample. Ultimately 28 sherds were selected for this study: 1 Style I, 21 Style III, and 6 indeterminate Style II or III sherds. Thin sections of these 28 sherds were made by Gomez Thin-Sections, Albuquerque, New Mexico. Each sherd was cut in cross section and then impregnated and mounted on slides with Epoxite, which has an index of refraction of

1.56. The thin sections were then ground to a thickness of 30 microns. Permount was used as a cover medium for the slides.

Analytical Methods

All analysis was performed at the Geology Department of the University of New Mexico on a Zeiss stereo petrographic microscope equipped with five objective lenses and a scaled ocular. Each sample was put on a mechanical stage, which overlaid the thin section with an evenly spaced array of data collection points. Several transects were made across the sample at intervals predetermined by the stage settings until a sample of 200 individual observations was made. All material directly in line with the cross hairs of the objective lens was recorded at each observation point. These raw counts were converted to percentage figures for data presentation (Appendix 9). The entire thin section was considered the sample universe; thus the data enabled estimates to be made of the volume of the temper components and matrix present in each sample. An effort was made to avoid point-count transects in areas on the sherds that were slipped or polished since such occurrences would bias results in favor of the matrix. In performing point counts, the analyst is obligated to identify whatever falls beneath the cross hairs. Although it is occasionally not possible to identify the materials since temper fragments or grain sizes may be too small and alteration may mask mineral characteristics, this circumstance occurred in less than one percent of the observations and thus should not significantly affect results. Despite the problems involved in performing point counts, it has been suggested that this methodology is essential to the creation of a large, quantitatively comparable data base (Rugge 1984).

Each sample was identified by a specimen number, which consisted of a batch number unique to each square kilometer in the survey area and a catalogue number unique to each collected artifact in that square kilometer. Information was recorded on all mineral and rock categories encountered at point-count transects in each thin section. Other attributes recorded were ceramic type, proportion of temper and matrix, maximum temper particle size, temper particle shape, and size sorting characteristics. Rock fragments made up a substantial portion of the temper in most samples. A total of 57 different rock categories were identified in this study. Most of these categories occur in only one sample, but a handful occur in several samples. Different rock categories may occasionally have been created for the same rock, because the size of rock fragments in the slides sometimes made precise identification difficult. It was decided that having the same rock type occur in two different categories was preferable to grouping different rocks under the same category. The mineralogic and textural descriptions for the 57 rock categories used in this study are given below.

Rock Category Descriptions

1) Few plagioclase, quartz and sanidine microphenocrysts, sparse biotite, oxyhornblende or magnetite psuedomorphous after oxyhornblende microphenocrysts in a matrix of stumpy feldspar laths, glass, and some opaque mineral and oxyhornblende grains.
2) Spherulite fragments: radial fibrous micro- to cryptocrystalline intergrowths that may contain some dendritic growths of opaque minerals.
3) Micro- to cryptocrystalline anhedral dusky quartz aggregates. These may be coarser grained portions of spherulites.
4) Fine grained altered alkali feldspar (may be orthoclase or sanidine or both), quartz, plagioclase, and muscovite in an altered cryptocrystalline matrix that may in part be extensively altered alkali feldspar.
5) Same as category 4 but without muscovite.
6) Plagioclase, quartz, and a few biotite microphenocrysts in a matrix of mostly micro- to cryptocrystalline material, probably quartz and alkali feldspar.
7) Few plagioclase microphenocrysts in glass.
8) Angular and embayed quartz microphenocrysts in a moderately clouded, micro- to cryptocrystalline matrix containing scattered opaque grains.
9) Plagioclase microlites with intergranular to subophitic opaques.
10) Anhedral and some rounded quartz microphenocrysts and a few small feldspar microphenocrysts in a slightly dusky cryptocrystalline matrix.
11) Quartz and plagioclase microphenocrysts in a heavily clouded cryptocrystalline matrix containing scattered opaques.
12) Quartz and plagioclase microphenocrysts in a cryptocrystalline matrix that is slightly stained with hematite.
13) Embayed sanidine and quartz microphenocrysts in a cryptocrystalline matrix containing some glass.
14) Plagioclase microphenocrysts in a cryptocrystalline matrix.
15) Embayed quartz and rare biotite microphenocrysts in a moderately dusky cryptocrystalline matrix.
16) A few stumpy feldspar laths, opaque grains, and a little glass in an otherwise heavily clouded cryptocrystalline matrix.
17) Subhedral sanidine microphenocrysts in a slightly dusky cryptocrystalline matrix containing much glass.
18) Quartz, embayed zoned plagioclase, and a few sanidine microphenocrysts in a slightly dusky cryptocrystalline matrix.
19) Plagioclase and embayed sanidine microphenocrysts in a lightly altered cryptocrystalline matrix containing a little glass and some areas of hematite staining.
20) Abundant angular and embayed plagioclase, sanidine, quartz, and rare o[illegible]blende microphenocrysts in a moderately dusky cryptocrystalline matrix.
21) Microcrystalline qu[illegible]
22) Rare quartz microphenocrysts in glass.
23) Few sanidine microphenocrysts and few spherulite fragments in a matrix of glass and cryptocrystalline material.
24) Feldspar microlites and opaque mineral grains in glass.
25) Cryptocrystalline material and glass with some hematite staining.
26) Microcrystalline quartz aggregates in an opaque matrix.
27) Plagioclase microlites with intergranular opaques and a little intersertal quartz and/or alkali feldspar and a very little intergranular pyroxene.
28) Plagioclase microlites scattered in hematite.

29) Anhedral angular quartz and rounded plagioclase microphenocrysts in glass.

30) Zoned plagioclase phenocrysts in a microlite matrix.

31) Rounded fine-grained quartz aggregate (quartzite).

32) Angular quartz and plagioclase microphenocrysts in a cryptocrystalline partially glassy matrix.

33) Plagioclase, sanidine, oxyhornblende and opaques in a microcrystalline matrix, probably composed of quartz and alkali feldspar.

34) Few angular quartz grains and spherulite fragments in clouded glass.

35) Quartz, sanidine and a few biotite microphenocrysts in a slightly dusky, micro- to mostly cryptocrystalline matrix.

36) Angular quartz, sanidine, and a few plagioclase microphenocrysts in a heavily clouded cryptocrystalline matrix.

37) Few sanidine microphenocrysts, scattered feldspar laths, and a few opaque grains in glass.

38) Rounded quartz, a few plagioclase and a very few angular altered alkali feldspar microphenocrysts in a moderately dusky cryptocrystalline matrix.

39) Angular plagioclase, quartz, a few biotite and opaque mineral microphenocrysts in a heavily clouded, part-glass part-cryptocrystalline matrix.

40) Quartz and lightly altered sanidine phenocrysts, a few plagioclase and biotite microphenocrysts in a slightly dusky, micro- to mostly cryptocrystalline matrix.

41) Slightly dusky cryptocrystalline material, probably quartz and alkali feldspar, and a few small opaque grains.

42) Micro- to cryptocrystalline quartz and feldspar with a few scattered opaque grains and a little glass.

43) Quartz and spherulite fragments in a heavily clouded glass.

44) Pale brown glass.

45) Micro- to cryptocrystalline quartz having undulatory extinction.

46) Angular quartz fragments about 0.5 mm across in a matrix of angular quartz fragments less than 0.1 mm across.

47) Plagioclase microphenocrysts in a moderately dusky matrix of feldspar microlites and a little glass

48) Xenomorphic granular quartz monzonite composed of lightly altered orthoclase, lightly to moderately altered plagioclase, and quartz.

49) Unknown (unidentifiable) rock fragments.

50) Micro- to cryptocrystalline calcite or dolomite (limestone?).

51) Microglomeroporphyritic plagioclase, quartz and sanidine microphenocrysts in a slightly clouded microcrystalline matrix composed of quartz, alkali feldspar, and a few opaque grains.

52) Heavily clouded cryptocrystalline material.

53) Cryptocrystalline mass of quartz(?) and scattered opaques.

54) Fragments of quartz, oxyhornblende, and plagioclase scattered in hematite.

55) Plagioclase microlites to small microphenocrysts, subophitically enclosed in a cryptocrystalline matrix with a few intergranular opaque grains.

56) Altered (devitrified) glass.

57) Small altered feldspar microphenocrysts in a microcrystalline matrix.

Geological Interpretation

The majority of the tempering materials found in the 64 Mimbres ceramics analyzed in this study are derived from volcanic rocks, and most of these tend to be acidic in composition. Some sherds contain subrounded fragments of as many as six distinct rock types, indicating the use of heterogenous mature stream sands as tempering material. Most, however, contain angular to subangular fragments of only one or two different rock types, indicating the use of sands that have undergone relatively little transport. It is possible that, in some cases, rocks were intentionally ground to the desired size for temper particles, but the evidence is equivocal.

If rock names were applied to the source rocks of the tempering materials observed in this study, most would be tuffs, vitric tuffs, rhyolites, or latites. The important question here is the origin of these rocks. Currently, all that can be done is to compare the petrographic data obtained in this study with information on rock types available in the geological literature covering south-central New Mexico. Ideally, this comparison would be followed by the collection and subsequent petrographic analysis of sand samples from suspect temper procurement locations to verify the tentative conclusions derived from the study of the geological literature. This step is outside the scope of the current study, but can be proposed as a logical follow-through from this study.

A thorough review of the geological literature surrounding the study area was conducted. Publications on the Jarilla, Franklin, Hueco, Organ, San Andres, and Sacramento mountains were studied to assess the rock types available in the region. The literature search showed that acidic volcanic rocks, whose texture and mineral composition roughly correspond to the vast majority of tempering materials observed in the 28 Mimbres ceramics analyzed from the Border Star 85 survey area, occur closest to the study area in the Organ Mountains. These rocks generally outcrop over the southwestern quarter of the Organs, and material derived from these rocks is the primary component of alluvial fans stretching west into the Rio Grande Valley and south toward the Franklins. In fact, Seager (1981) states that material derived from the Squaw Mountain tuff forms much of the west pediment of the Organ Mountains.

While this is the closest occurrence to the study area of such rocks, it is not the only area in south-central New Mexico where rocks of this composition and texture are found. As Seager (1981) points out, the tuffs in the Doña Ana Mountains 24 km (15 mi) northwest of the Organs are very similar to the tuffs of the Organ Mountains. Volcanic rocks of similar mineral composition and texture outcrop in numerous areas around south-central and southwest New Mexico, including some parts of the Mimbres Valley. Consequently, defining the source areas of the tempering materials found in the Mimbres ceramics analyzed in this study becomes a difficult task. Just because certain samples contain particular rock types, it cannot be said unequivocally that they are derived from a specific location. Furthermore, a geological interpretation of the data, without additional field research, is not sufficient to answer the questions raised in this study.

Results

After the analysis was completed, a temper classification scheme was devised for the 64 samples (Appendix 9). The intent was not to define temper categories in the sense of mutually exclusive associations of rock and mineral fragments that could then be interpreted as being representative of discrete resource procurement locations and/or production localities. Instead, the intent was to group samples containing similar rock and mineral types that could indicate clusters of procurement locations in close proximity but discrete from each other. The groupings created do not necessarily represent a specific resource procurement location. This classification scheme enabled a discussion of the distribution of samples that appeared to be manufactured with similar materials. Table 14.1 lists the groups and the samples placed in each group.

The largest single group, Group 1, contains 14 samples: 8 from the Border Star 85 survey, 2 from the Fairchild site, and 3 from the Mimbres Valley. Group I is characterized by the presence of two rock types: a latite, which contains very few phenocrysts of plagioclase, quartz, sanidine, and (rarely) biotite in a matrix that consists of stumpy feldspar laths, microphenocrysts of oxyhornblende, scattered opaque mineral grains, and glass; and spherulites, which typically have a fibrous radial habit and may contain dendritic growths of opaques. The occurrence of the latite is unique to this group, and oxyhornblende is also a conspicuous mineral constituent of these samples. Most of the samples in this group are from the Border Star 85 survey area; thus, it is tentatively suggested that this material derives from what Seager (1981) has called the West Side Lavas, which are noted as containing oxyhornblende in some flows.

Table 14.1. Samples included within temper groups (identified by specimen number)

Temper Group	Source	Sample Numbers
1	Fairchild	FS 264, FS 284
	Mimbres Valley	84-67-199, 84-67-202, 84-67-220
	Border Star 85	186-14, 185-01, 142-2-1, 142-2-2, 182-28, 220-05, 072-06, 185-20, 185-71
2	Fairchild	FS 293-3, FS 167, FS 265-1
	Mimbres Valley	84-67-201
	Border Star 85	185-27
3	Mimbres Valley	84-67-106, 84-67-107
	Border Star 85	182-52
	Ft. Bliss	72-24-265
4	Border Star 85	182-23
	Ft. Bliss	77-18-207, 77-18-315, 77-18-323
5	Border Star 85	073-03
	Ft. Bliss	77-18-250, 72-24-243
6	Fairchild	FS 157
	Mimbres Valley	84-67-198
	Ft. Bliss	72-24-232
7	Border Star 85	073-72
	Ft. Bliss	76-16-272

These rocks occur on the west side of the Organ Mountains. Oxyhornblende also occurs in rocks in the Lake Valley quadrangle (Jicha 1954), but Jicha's photomicrographs and descriptions of rocks containing that mineral do not resemble the latite described in this group. Similarly, Elston (1957) reports the occurrence of oxyhornblende in latites in the Mimbres Valley, but the rock descriptions do not match those observed in Group 1.

Group 2 contains five samples: three from the Fairchild site, one from the Mimbres Valley, and one from the Border Star 85 survey area. The group is characterized by a rock made up mostly of quartz, plagioclase, and altered alkali feldspar, which may be both sanidine and orthoclase in a cryptocrystalline matrix that may in part be extensively altered alkali feldspar. The mineral muscovite also occurs in this rock and is abundant in some samples. Muscovite, unobserved in any other grouped or ungrouped samples, does not match any of the descriptions encountered in the geological literature review; however, since it occurs most often in samples from the Fairchild Site, it probably outcrops closer to that locality than to the Mimbres Valley or the Border Star 85 survey area.

Group 3 contains four samples: two from the Mimbres Valley, one from the Border Star 85 survey area, and one from Ft. Bliss. This group is identical to Group 2 but for the absence of muscovite. Because of the alteration of the rock that is the source of the tempering material it is difficult to define. No rock closely resembling this temper was found in the geological literature reviewed.

When Groups 2 and 3 are combined we find that the resulting temper category is represented in samples from all the areas included in this study. These two groups occur most frequently in samples from the Fairchild Site: 3 of the 12 samples exhibit this temper, as do 3 of the 15 samples from the Mimbres Valley. The distribution suggests that both areas may have had exchange relations with a third area where these ceramics were produced.

Group 4 also contains four samples: three from Ft. Bliss and one from the Border Star 85 survey area. The temper consists of some angular anhedral and some embayed quartz microphenocrysts in a cryptocrystalline matrix that is slightly dusky with opaques. The rock is probably a rhyolite or rhyolitic tuff.

Group 5 contains three samples: two from Ft. Bliss and one from the Border Star 85 survey area. It is characterized by rock fragments that are mostly glass.

Group 6 contains three samples: one from Ft. Bliss, one from the Mimbres Valley, and one from the Fairchild site. It is characterized by rock fragments that are spherulites. Since spherulites occur in numerous localities from the Mimbres Valley to the Organ Mountains, the significance of this grouping and its utility as an analytical unit are highly questionable.

Group 7 contains two samples, one from Ft. Bliss and one from the Border Star 85 survey area. It is characterized by a rock that consists of plagioclase phenocrysts, fewer quartz and a few biotite microphenocrysts in a microcrystalline matrix. This rock generally resembles some of the

rocks occurring in the West Side Lavas of the Organ Mountains.

An additional group can be defined based not upon a unique mineralogy or lithology but upon the presence of subrounded to rounded particles of a wide variety of different rock types. As mentioned earlier, these heterogenous mature sands were sometimes used in the production of Mimbres ceramics. It is very difficult to assign possible source areas when tempering materials are composed of fairly mature sands, because these sands may have traveled quite some distance from their source areas. In addition, variability is so great in the southcentral and southwest part of New Mexico that rock mineralogies and textures can be duplicated over many localities. No attempt will be made in this report to assign specific source areas for temper composed of heterogenous mature sands. Because none of the Mimbres Valley samples contain mature sands as tempering material, however, it can be suggested that production of Mimbres ceramics using mature sands occurred exclusively outside of the Mimbres Valley. Such an occurrence is especially likely since the heterogenous mature sands were probably from the Rio Grande Valley. Seven samples can be placed in this group: BS142–3, BS2–12, and BS182–10 from the Border Star 85 project and FS233, FS256, FS272, and FS581 from the Fairchild Site.

Conclusions

While the conclusions derived from this study are not as definitive as might have been hoped, two points have become clear. First, Mimbres series ceramics were produced over a broad geographic range and at a number of different localities, as is evidenced by the diverse mineralogic, lithologic, and textural range of tempering materials observed. The geographic range of production may extend as far east as the western slope of the Organ Mountains and almost certainly includes numerous locations in the Rio Grande Valley. Certain tempering materials, specifically heterogenous mature sands, are here interpreted as being indicative of production in the Rio Grande Valley, and these materials were not observed in Mimbres ceramics analyzed from the Mimbres Valley. The available evidence thus demonstrates that, contrary to the view of LeBlanc and Whalen (1980), Mimbres ceramics occurring in the Tularosa Basin were probably not the exclusive result of low level interaction with the core Mimbres area in southwestern New Mexico.

Carmichael's (1983) suggestion that Mimbres ceramics may have been produced in the Jornada Mogollon region and continued to be produced there after the depopulation of the Mimbres Valley seems to be supported by the petrographic evidence. Furthermore, it is quite possible that Mimbres Black-on-white continued to be manufactured and distributed regionally, perhaps from the Rio Grande Valley, after the depopulation of the Mimbres Valley. How much longer it was manufactured and distributed is a question that must wait for chronometric dates in firm association with Mimbres Whitewares.

The production areas do not, however, appear to be located in the Tularosa Basin. Although in a very few cases tempering materials correspond to materials that could be available in the Tularosa Basin, specifically FS293-1 and 72-24-250, those materials do not occur exclusively in that area. Additionally, studies in the Tularosa Basin (Rugge 1978, 1985a) show that the tempering material used in locally produced painted and plain wares is without exception a crushed granite consisting largely of microperthite and quartz. This material was not observed in any of the 64 Mimbres series ceramics considered in this study.

Second, the wide geographic distribution of samples containing similar tempering materials, specifically Groups 1, 2, and 3, suggests an extensive interregional exchange of Mimbres ceramics. Currently, data are insufficient to determine the directions of this exchange or the production localities for ceramics within these groupings. Once again, however, production exclusive to the core Mimbres area is ruled out. In fact, the tempering materials in the Mimbres Valley samples are as diverse as those from the Tularosa Basin. This diversity may to some extent be attributable to exchange with other areas in which Mimbres ceramics were produced, as well as to the range of production localities within the Mimbres Valley.

Some comments can be made about the nature of exchange systems involving the movement of Mimbres ceramics into the Tularosa Basin. LeBlanc and Whalen (1980) have suggested that transmission between neighboring villages of a few nonlocal items characterized the mechanisms of trade into the Jornada Mogollon region. Robinson (1980) similarly suggested that interregional exchange with the Jornada area was characterized by down-the-line trade until about AD 1100, at which time he suspects that trade became more centrally organized. The down-the-line exchange idea, however, seems to be inextricably linked to the supposition that Mimbres ceramics simply flowed outward from the core Mimbres area, and, as we have seen, this supposition is probably incorrect. Robinson (1980) concludes that interregional exchange of Mimbres series ceramics in the Reserve area was governed by a central place distribution mechanism—that is, ceramics moved on an interregional level between local redistribution centers. Current evidence for exchange of Mimbres ceramics in south-central New Mexico does not support the down-the-line trade model, and it may well be that a more complex trade mechanism similar to that discussed for the Reserve area was in operation.

Chapter 15

PROJECTILE POINT ANALYSIS

James O'Hara

One of the goals of the Border Star 85 archeological project is to document the major periods of prehistoric occupation within the southern portions of the Tularosa Basin. Since most of the data obtained during this survey cannot be used to provide absolute dates, we are dependent on the relative chronologies derived from the artifact typologies that exist for this area. Projectile points or hafted bifaces constitute a class of artifacts that has long been recognized as both chronological and cultural markers. The changes in morphology from one distinct form to another have been documented across regions of the Southwest and elsewhere. Temporal designations are made when distinct styles of points can be dated according to stratigraphic superpositions or with more accurate chronometric techniques. Temporal designations are often applied to all examples similar to a particular type.

The goal of this study, therefore, is to fit the projectile points collected from Phase I of the Border Star 85 survey into known typologies and to identify possible elements of a separate local sequence. Once strong morphological similarities can be identified between the projectile points recovered during Phase I survey and known regional types, important information relating to chronology can be extrapolated. In order to accomplish this it will be necessary to (a) identify known regional typologies that can be used for comparison with the, as yet unidentified Phase I projectile points; (b) establish a means by which the unknown points can be typologically classified as accurately as possible; and (c) establish a typology for projectile points found during the Border Star 85 survey, thereby providing a relative chronology for prehistoric use of the project area.

Appropriate Regional Typologies

The most appropriate typology would be, of course, one defined for the Tularosa Basin. Although a considerable amount of archeological work has been undertaken in the Tularosa Basin, most of it has been restricted to survey (e.g., Beckes 1977; Carmichael 1983; Eidenbach and Wimberly 1980; Skelton 1981; Wimberly and Rogers 1977). Relatively little work has been conducted or reported from excavations of sites with the potential of contributing to a basin-wide chronological typology (cf. Anyon 1985; Eidenbach 1983). Perhaps the best example is Fresnal Shelter, which remains largely unreported (Human Systems Research 1972; 1973b).

Archeologists create typologies based on morphological traits from a particular region or depend upon better defined typological sequences from other regions. Three different regional typologies have been defined from areas in and around the Border Star 85 project area: the Trans-Pecos, Cochise, and Oshara. All of these typologies will be included in this study and will provide a wide range of forms that can be used for comparisons.

Trans-Pecos

The Trans-Pecos sequence of projectile points has been defined chiefly from archeological investigations conducted in Texas. The region lies between the Pecos River and the Rio Grande and extends from the Big Bend area of the Texas-Mexico border in the south northward to the Guadalupe Mountains in the northwestern portion of Texas. Environmentally this area is the north-central portion of the Chihuahuan Desert (Mallouf 1985). An extensive quantity of archeological information has been collected for all major prehistoric phases: Paleoindian, Archaic, and post-Archaic. Consequently, a fairly well-established typology is available for comparison. Although there may not be a consensus on the exact chronology for this typology, a number of relative temporal divisions have been proposed. The Trans-Pecos is said to represent a major cultural tradition, that is, one transitional between the Eastern Archaic and the Desert Archaic of the Southwest (Willey and Phillips 1958).

Cochise

The Cochise tradition is viewed as a regional variant of the Desert Archaic. This tradition, first described by Sayles and Antevs (1941), probably extends from eastern Arizona through New Mexico and into northern Mexico (Beckett 1973). Excavation of such major sites as Double Adobe (Sayles 1983) and Ventana Cave (Haury 1950) in Arizona and the Wet Leggett site (Martin et al. 1949) in western New Mexico have led to the establishment of a three-phase sequence for the Cochise: Sulphur Springs, Chiricahua, and San Pedro. Another phase, the Cazador, has been postulated; however, it is probably a variant of the Sulphur Springs phase (Beckett 1973; Sayles 1983). The sequence has also been documented in New Mexico at Bat Cave (Dick 1965) and the Ake site (Beckett 1980).

Oshara

The Oshara tradition was first defined by Irwin-Williams (1973) from excavations of sites near the Puerco River in north-central New Mexico. The geographic distribution and temporal sequences of the Oshara are still relatively unknown. The best information limits major examples to the

Colorado Plateau of northern New Mexico, northeastern Arizona, and southwestern Colorado. The phases identified by Irwin-Williams (1973, 1979; Irwin-Williams and Tompkins 1968) are Jay, Bajada, San Jose, Armijo, and En Medio. Even though the Oshara is still being defined, it may prove to be a useful typology to include in this study.

These cultural traditions and associated projectile point typologies represent the best information available for comparative purposes. The next stage of this analysis is to develop a methodology that will allow us to typologically classify the projectile points collected during Phase I survey.

Analytical Methods

Two major approaches are available for creating hafted biface typologies: subjective and objective. The subjective approach relies on the ability of the person typing the points to identify morphological differences. The archeologist forms a mental template for each type based on morphological similarities or differences. The main advantage to this approach is that it is easily performed, but such a purely subjective approach can lead to problems in consistency and replication. What is seen by one person as an important attribute may not be seen as critical by others.

An objective approach usually implies the integration of statistical methods to help define each distinct type. The advantages of this technique center on the creation of a methodology that can be consistently repeated by anyone. One possible disadvantage is the increase in the amount of time required for the analysis; in addition, this method depends upon the availability of computers to perform the statistical analysis.

This study was initiated as an objective statistical approach. The analysis of Border Star 85 projectile points was fashioned after work done by Holmer (1978, 1980). Holmer's technique employs three basic steps. First, it is necessary to identify typologies that are relevant to the study area. A number of drawings or photographs of projectile points representative of these typologies are collected and referred to as the control group. The x and y coordinates of a number of defined places on each specimen are recorded using a digitizer, or other appropriate method, in order to monitor various changes in morphology (Figure 15.1). The second step is the conversion of the x and y coordinates, using mathematical formulas, into variables that define the various morphological attributes of each hafted biface (Table 15.1). The same measurement strategy is applied to those points that must be categorized. A data set of the morphological attributes is then created for both the control group and the set of unidentified projectile points (in this case the Phase I specimens).

The final step is devoted to defining mathematically the morphological attributes for each different control type. In this method, discriminant analysis is used to assist in the definition of each individual type. The results of this analysis include a mathematical model (discriminant function), which describes each distinct typological class, along with a proposed reclassification of any control type

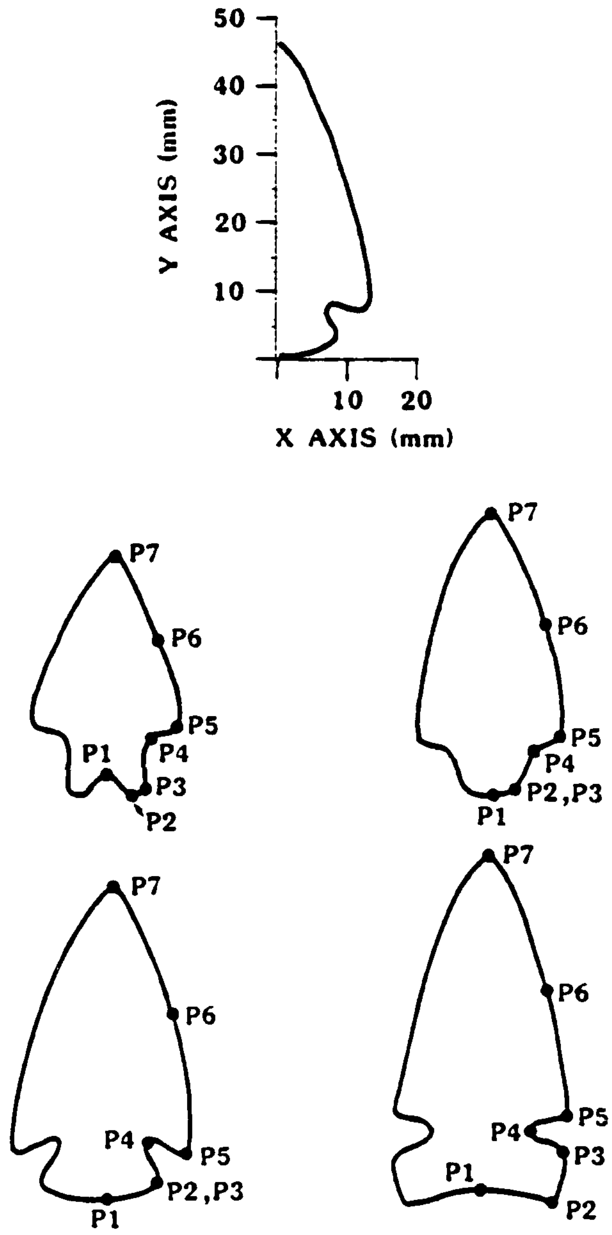


Figure 15.1. Coordinate points employed in digitizing projectile points (after Holmer 1978)

considered by application of the model to be incorrectly classified. The values of the unknown projectile points are then evaluated against each mathematically derived class until all are placed into a unique type. Since the discriminant analysis is the most critical step in the process, it is useful to discuss exactly how it produces results.

Discriminant analysis is a statistical procedure that simultaneously monitors the differences among groups of interval variables with respect to a number of nominal

Table 15.1. Variables used in the projectile point analysis

Variable	Definition
M1	distance from P1 to P2
M2	distance from P2 to P3
M3	distance from P3 to P4
M4	distance from P4 to P5
M5	distance from P3 to P5
M6	length of point
M7	width of point
A1	angle from P1 to P2
A2	angle from P2 to P3
A3	angle from P3 to P4
A4	angle from P4 to P5
A5	angle from P3 to P5

Note: All angles measured from horizontal
(Derived from Holmer 1978:9)

classes—in this case, distinct projectile point types. The goal is to identify the set of variables that are the best predictors of each nominal class (Klecka 1982). The discriminating variables, or best predictors, can be combined to create a number of discriminant functions. Each function will identify a nominal class and will help to differentiate among a number of nominal classes. Discriminant functions are most commonly expressed as multiple regression models (Klecka 1982; Lachenbruck 1975; Van de Geer 1971).

The control groups for this study are representative of the three typological sequences discussed earlier. Projectile point illustrations for the Oshara and Cochise traditions were taken from Beckett (1983), Del Bene and Ford (1982), Dick (1965), Eidenbach (1983), Elyea et al. (1979), Reher (1977), and Simmons (1982). Examples of the Trans-Pecos typology were taken from Suhm and Jelks (1962). The minimum of eight projectile points for each type used in this study is based on Holmer's estimate for a valid sample size taking into consideration a measurement accuracy of ±3.5 mm with a confidence level of 95 percent (1.96 standard deviation units) and a standard deviation of no more than 5.0 mm for each digitized coordinate (Holmer 1980:64). Once the results have been obtained, this minimum sample size can be evaluated.

The discriminant analysis was conducted in two stages. First, the discriminating variables that best defined the nominal classes were selected using the control data set. A step-wise discriminant analysis was used to select these variables because this procedure (a) identifies the best discriminating variable; (b) performs a pair-wise selection with each remaining variable to determine which combination makes the best discriminating model; and (c) allows the retention of only those variables that significantly add to the model (Klecka 1982:52–54).

The selection of variables is based on the Wilks' lambda and multivariate *F* statistics. The lambda is a multivariate measure of the differences among classes and of the degree to which classes are cohesive or homogeneous based on class centroids (Klecka 1982:39, 54). The lower the Wilks' lambda, the stronger the discriminatory power of the variable. The *F*-test can use either the overall *F* statistic, generated from the Wilks' statistic, or a partial *F*. The higher the *F* value, the greater the discriminatory power of a variable (Klecka 1982:55).

The second stage of analysis is the generation of mathematical models for each control group (in this case, for each projectile point type). The discriminant analysis program uses values from the "best" discriminating variables. All projectile points in a particular control group are evaluated together, resulting in a mean for each variable in a control group. The vector of means is referred to as a class centroid and is used to create a mathematical function that represents the "best" description of a type.

A measure called the pair-wise squared generalized distance between groups (based on the Mahalanobis generalized distance) becomes important at this stage of the analysis. This statistic measures the distance between class centroids and also the dispersion of points around each centroid. The higher the dispersion of values around a centroid, the more likely it is that an overlap between different types will occur. Point types whose centroids are separated by small distances will have a greater degree of overlap—that is, they will appear more similar (Lachenbruck 1975:5) than types with widely spaced centroids. Assignment of a specimen to a particular type is based on the generalized distance between the location of the specimen in *n*-dimensional space and all type centroids. The closer a value is to the centroid of a given type, the greater the probability of its inclusion in that type. Thus, the generalized distance statistic is an important tool for interpreting the results of the discriminant analysis.

It is possible that some of the control specimens could be reclassified, which would depend on how similar the specimens are within each type class. When forms are similar, reclassifications will occur. We can monitor reclassifications using the generalized squared distance between types. For example, reclassification will occur when the squared distance values for two class centroids (two different types) are similar. In these situations, the clusters of data values around the centroids are dispersed, resulting in a partial overlap of value distributions. Consequently, corresponding hafted bifaces lying in the area of overlap may be reclassified (Figure 15.2).

Another possible example of control type reclassification will occur when there is a high degree of variability in the dispersion of data values around a centroid. When the values for hafted bifaces assigned to a particular type are not closely clustered around the centroid value for that type, the variability, if extensive, will result in one highly dispersed class overlapping a number of other types that have very tight clusters of observations. This situation will result in the observations from the poorly defined type being reclassified into one or more of the other types (Figure 15.3).

Typological Comparisons

The first stage in the statistical analysis of the Border Star 85 projectile points was the identification of those varia-

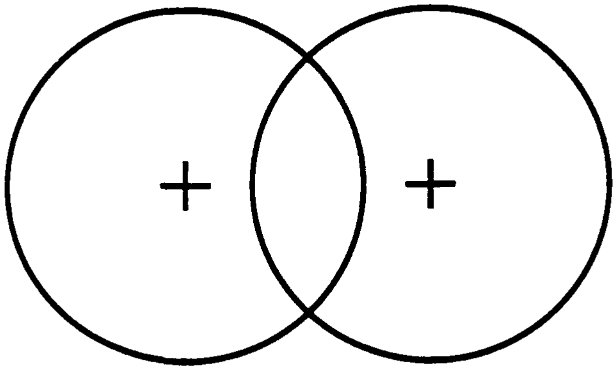


Figure 15.2. Illustration of overlap between distributions of data points around two centroids

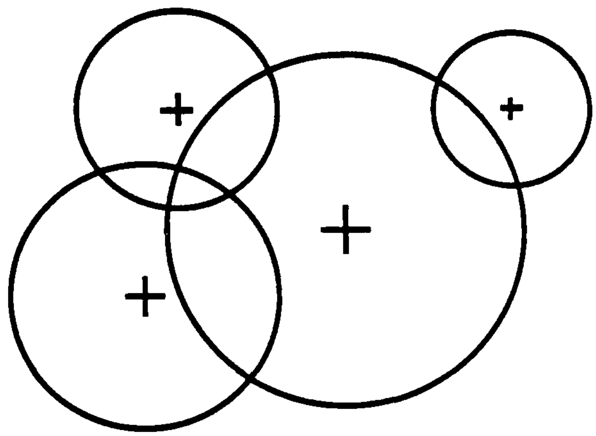


Figure 15.3. Illustration of how variable clusters can be reclassified in several other types

bles (computed from the digitized point measurements) that could be used to generate the best discriminant functions for the control types. A step-wise discriminant analysis using the SAS "STEPDISC" procedure (Statistical Analysis System [SAS] Institute 1982b:405) had been conducted for a previous study (O'Hara and Elyea 1985). Since many of the specimens used in that study are included in the control types for the present study, it is appropriate that the present analysis remain consistent with that of the previous study. Table 15.2 lists the variables selected and their corresponding Wilks' lambda and *F* statistics. Variables A1 and M1 have the highest discriminatory values; M7 through A4 are less effective as discriminators but contribute significantly to the models for each type. Each variable characterizes some morphological feature of the haft element (Figure 15.4). When combined, these variables will be the basis for the multiple regression models used to describe mathematically each of the control types. One additional variable will be added to this list: M8, the ratio of haft width to haft length (M8 = M1/M3). This variable has been added to provide a relative measure of the proportions of the haft. It is believed that M8 will add to the discriminatory power of the other important variables.

Figure 15.4 illustrates the attributes being monitored. A1 describes basal shape—concave, convex, or straight. M1 measures the width of the base. M7 is the width of the point measured at the shoulders; this measure may also represent the maximum width. M5 measures the distance from the edge of the blade shoulder to the intersection of the haft element and the blade. This variable monitors both the size of the notches and the general shape of the intersection between the haft element and the blade. M4 measures the shoulder length, while M3 measures the distance from the proximal edge of the base to the intersection of the haft element and blade. This measurement either represents the notch width or length of the haft element. A4, the final discriminant variable in Table 15.2, measures the angle formed by the shoulder.

These discriminatory variables were used to create mathematical models describing each projectile point type in the control data set. The models were created during the discriminant analysis using the "DISCRIM" procedure in SAS (1982b:381). A "best" multivariate linear model was created to describe each point type, based on the class centroid (mean). The DISCRIM analysis uses these models in two ways. The values for each artifact in the control data set are compared to the centroid-based models of all other types; for example, if the value of a specimen falls too far from its class centroid, then that biface is reclassified. When a point falls within the acceptable range of variability defined for its control group, it is classified in that type. The probability that an item is correctly classified is calculated as the *posterior probability of membership*. The maximum score for this value is 1.00, but any item may have some probability of membership in more than one type. The highest value represents the type that the model determines to be the "best" description.

Table 15.2. Discriminatory variables chosen in step-wise analysis

Step	Variable Entered	Partial R^2	F	Prob. >F	Wilks' Lambda
1	A1	0.6992	15.570	0.0001	0.30075952
2	M1	0.6843	14.307	0.0001	0.09494522
3	M7	0.5303	7.339	0.0001	0.04459592
4	M5	0.4801	5.910	0.0001	0.02318632
5	M4	0.3446	3.313	0.0017	0.01519592
6	M3	0.3629	3.532	0.0010	0.00968116
7	A4	0.2698	2.254	0.0258	0.00706916

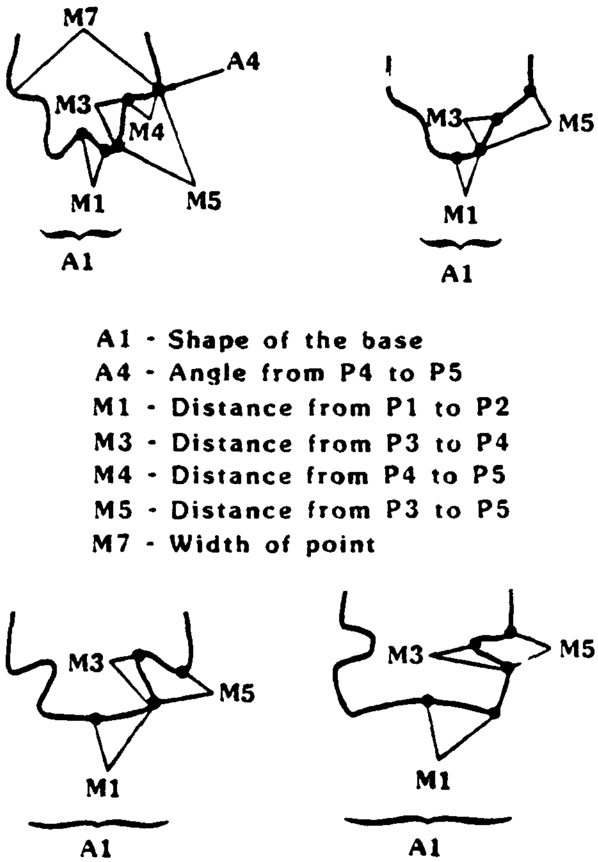


Figure 15.4. Haft elements monitored by the discriminating variables

After the control points have been analyzed and evaluated and the reclassifications have been completed, the discriminant analysis can be expanded to include an unknown data set—in this case the Border Star 85 Phase I data. The DISCRIM procedure will compare each unknown item to all of the control type models. A type designation will be assigned when a point best fits an individual model. These designations will also include a posterior probability of membership. One important fact that should be kept in mind is that the DISCRIM procedure produces and uses a finite set of models for hafted biface types. The procedure cannot create *new* categories, nor can it designate items as true "unknowns." All points will receive a type designation even if there are few morphological similarities. The "best" fit is determined by the models. When there is no well-defined typology, it is necessary to evaluate the results to determine the accuracy of the classification. The calculated posterior probabilities will be an important criteria for evaluating how well each item was classified.

A total of 288 artifacts were included in the 25 control type classes (Table 15.3). Initial analysis of these types resulted in reclassification of almost half of the control groups. This failure of the control types to remain distinct was not totally unexpected. At least two explanations exist for this degree of reclassification. The first is the morphological similarities between some of the control types. When morphological similarities occur between two distinct types there is a tendency for interchangeable reclassifications. The problem is also compounded by the degree of morphological variability that exists within any distinct typological unit. The points used for the control types were subjectively identified, often by different individuals; thus a heterogeneous grouping of points was produced. Figure 15.3 is a graphic representation of this problem. Although distinct types are identified, class centroids can be relatively similar, and class membership tends to overlap.

Table 15.3. Projectile point control types

Type	Frequency	Prior Probability
Jay	7	0.04
Bajada	11	0.04
San Jose	17	0.04
Armijo	13	0.04
En Medio	19	0.04
Augustin	19	0.04
San Pedro	21	0.04
Chiricahua	21	0.04
Shumla	10	0.04
Ellis	9	0.04
Marcos	6	0.04
Ensor	9	0.04
Scallorn	12	0.04
Angostura	8	0.04
Edgewood	9	0.04
Darl	12	0.04
Carrolton	9	0.04
Bullverde	10	0.04
Langtry	10	0.04
Nolan	6	0.04
Paisano	9	0.04
Palmillas	9	0.04
Pendale	8	0.04
Pedernales	16	0.04
Uvalde	8	0.04
Total	288	1.00

Even though reclassifications did occur, it is possible to explore the statistical similarities among types. Table 15.4 is the compilation of reclassification information, including a listing of generalized squared distance to type measures. Each type class is listed with the number of times a member of that class was reclassified into other classes. Next to the reclassifications list are the appropriate generalized squared distances between the original and the reclassified types (a complete list for all types is included in Table 15.5). Of the 115 control artifacts reclassified, 63 percent were reclassified into other types where the generalized squared distance was 5.65 or less. Lower measures represent the morphological similarities between artifacts. The remaining 37 percent are examples of the high degree of variability that often exists within some point types. The data from Table 15.4 indicate why some types are reclassified interchangeably.

Table 15.4. Reclassification data

Type	Total	Reclassification Type	(No.)	Squared Distance
Angostura	8	San Jose	(1)	20.81
		Nolan	(1)	4.43
		Angostura	(6)	—
Armijo	13	Ellis	(1)	4.40
		Scallorn	(3)	4.43
		Angostura	(1)	29.29
		Edgewood	(2)	4.41
		Nolan	(1)	18.07
		Paisano	(5)	—
Augustin	19	Augustin	(19)	—
Bajada	11	Pandale	(1)	3.24
		Bajada	(10)	—
Bullverde	10	Bajada	(1)	14.01
		Carrolton	(2)	5.86
		Pedernales	(1)	7.63
		Bullverde	(6)	—
Carrolton	9	Bullverde	(2)	5.86
		Langtry	(1)	0.86
		Nolan	(1)	2.48
		Carrolton	(5)	—
Chiricahua	21	San Pedro	(1)	4.45
		Ensor	(1)	2.96
		Darl	(1)	13.86
		Paisano	(6)	7.17
		Chiricahua	(12)	—
Darl	12	San Jose	(2)	8.35
		Ellis	(1)	4.15
		Paisano	(2)	2.78
		Pandale	(2)	5.65
		Darl	(5)	—
Edgewood	9	En Medio	(1)	1.77
		Ellis	(3)	1.61
		Palmillas	(2)	2.54
		Edgewood	(3)	—
Ellis	9	En Medio	(2)	1.40
		Edgewood	(1)	1.61
		Darl	(1)	4.15
		Palmillas	(1)	2.34
		Ellis	(4)	—
En Medio	19	Augustin	(1)	12.19
		San Pedro	(1)	5.20
		Ellis	(4)	1.40
		Ensor	(1)	4.19
		Edgewood	(4)	1.77
		Bullverde	(1)	18.48
		En Medio	(7)	—
Ensor	9	En Medio	(1)	4.19
		San Pedro	(2)	2.56
		Chiricahua	(1)	2.96
		Scallorn	(1)	2.99
		Edgewood	(1)	5.78
		Ensor	(3)	—
Jay	7	Nolan	(3)	4.43
		Jay	(4)	—
Marcos	6	Marcos	(6)	—
Nolan	6	Jay	(1)	4.43
		Augustin	(1)	10.04
		Pandale	(1)	2.89
		Nolan	(3)	—
Paisano	9	San Jose	(2)	4.54
		Augustin	(1)	9.99
		San Pedro	(1)	6.13
		Chiricahua	(1)	7.16
		Paisano	(4)	—
Palmillas	9	San Pedro	(1)	6.67
		Ellis	(2)	2.34
		Paisano	(1)	7.18
		Uvalde	(1)	2.51
		Palmillas	(4)	—
Pandale	8	Jay	(1)	7.68
		Bajada	(1)	3.24
		Darl	(1)	5.65
		Pandale	(5)	—
Pedernales	16	Bajada	(2)	9.82
		San Jose	(1)	9.84
		Shumla	(1)	32.55
		Carrolton	(1)	13.32
		Bullverde	(1)	7.63
		Pedernales	(10)	—
San Jose	17	Bajada	(1)	6.59
		Darl	(3)	2.94
		Paisano	(1)	4.54
		San Jose	(12)	—
San Pedro	21	Augustin	(1)	9.37
		Chiricahua	(1)	4.45
		Ellis	(2)	4.16
		San Pedro	(17)	—
Scallorn	12	En Medio	(2)	2.12
		Chiricahua	(1)	7.09
		Ellis	(1)	1.93
		Edgewood	(3)	2.47
		Scallorn	(5)	—
Shumla	10	Marcos	(1)	4.66
		Edgewood	(1)	21.66
		Palmillas	(1)	21.78
		Shumla	(7)	—
Uvalde	8	San Jose	(1)	8.48
		Edgewood	(1)	1.38
		Paisano	(1)	7.45
		Palmillas	(2)	2.51
		Pedernales	(1)	14.38
		Shumla	(1)	16.17
		Uvalde	(1)	—

Table 15.5. Squared generalized distances between control groups

$$D^2(I|J) = (\bar{X}_I - \bar{X}_J)' \, COV^{-1} \, (\bar{X}_I - \bar{X}_J)$$

GENERALIZED SQUARED DISTANCE TO TYPE

FROM TYPE	JAY	BAJADA	SAN JOSE	ARMIJO	EN MEDIO	AUGUSTIN
JAY	0.00000000	9.22363129	24.93555793	34.96275943	36.16191410	22.65095303
BAJADA	9.22363129	0.00000000	6.58636192	20.50109609	25.49237699	21.63658847
SAN JOSE	24.93555793	6.58636192	0.00000000	8.03864024	13.56196219	15.11204232
ARMIJO	34.96275943	20.50109609	8.03864024	0.00000000	5.53071694	11.84664366
EN MEDIO	36.16191410	25.49237699	13.56196219	5.53071694	0.00000000	12.18811141
AUGUSTIN	22.65095303	21.63658847	15.11204232	11.84664366	12.18811141	0.00000000
SAN PEDRO	39.64130772	27.72151701	15.13374546	5.91772124	5.20440112	9.97154404
CHIRICAHUA	54.36041744	32.13389522	16.27292452	8.16794691	12.17610233	23.28375265
SHUMLA	59.85894031	55.48777673	42.96560104	35.92277602	20.89674728	40.67532651
ELLIS	32.08864104	20.24008386	8.32043929	4.40460691	1.39817057	7.40620980
MARCOS	67.40442648	56.06661398	40.98996744	32.31591545	16.37539062	45.18225527
ENSOR	47.43559293	30.93882944	16.64253128	6.10213976	4.19182368	19.15791763
SCALLORN	45.02013153	28.15925744	12.25389297	4.43265482	2.12167237	12.89245507
ANGOSTURA	7.75776386	9.39181110	20.80986263	29.29493486	38.31873054	30.85290099
EDGEWOOD	35.72890850	22.96489281	10.16562828	4.41453872	1.77459097	10.37273484
DARL	22.88080617	9.95969572	2.93925420	4.55116193	7.90480285	7.59464507
CARROLTON	9.23045260	9.56724068	11.59957014	17.38929730	17.08318336	9.09416338
BULLVERDE	16.61044947	14.00926955	17.42466498	25.74295472	18.48216036	23.25637876
LANGTRY	7.75327768	8.20565415	12.60871582	19.50609953	22.05250047	12.08306170
NOLAN	4.42644785	7.66275755	12.93680527	18.06847728	18.35517266	10.04043297
PAISANO	34.72181329	17.33164548	4.54437460	2.10750576	8.69460189	9.99172347
PALMILLAS	27.03580145	22.21982784	12.63257955	5.13752126	3.26346325	4.63411153
PANDALE	7.68175136	3.24082878	6.45631174	12.18357164	17.54146282	11.21337038
PEDERNALES	26.11183461	9.82314027	9.84446935	26.14091463	24.98219794	32.79147821
UVALDE	29.30047167	18.44493766	8.48504057	6.35307271	3.09373825	10.41574454

$$D^2(I|J) = (\bar{X}_I - \bar{X}_J)' \, COV^{-1} \, (\bar{X}_I - \bar{X}_J)$$

GENERALIZED SQUARED DISTANCE TO TYPE

FROM TYPE	SAN PEDRO	CHIRICAHUA	SHUMLA	ELLIS	MARCOS	ENSOR
JAY	39.64130772	54.36041744	59.85894031	32.08864104	67.40442648	47.43559293
BAJADA	27.72151701	32.13389522	55.48777673	20.24008386	56.06661398	30.93882944
SAN JOSE	15.13374546	16.27292452	42.96560104	8.32043929	40.98996744	16.64253128
ARMIJO	5.91772124	8.16794691	35.92277602	4.40460691	32.31591545	6.10213976
EN MEDIO	5.20440112	12.17610233	20.89674728	1.39817057	16.37539062	4.19182368
AUGUSTIN	9.97154404	23.28375265	40.67532651	7.40620980	45.18225527	19.15791763
SAN PEDRO	0.00000000	4.45412354	39.87334893	4.16380821	37.15079304	2.55782695
CHIRICAHUA	4.45412354	0.00000000	50.26999904	11.03523340	44.76456445	2.96136006
SHUMLA	39.87334893	50.26999904	0.00000000	24.84637232	4.65770593	33.39325601
ELLIS	4.16380821	11.03523340	24.84637232	0.00000000	22.56240280	5.65714494
MARCOS	37.15079304	44.76456445	4.65770593	22.56240280	0.00000000	27.56636496
ENSOR	2.55782695	2.96136006	33.39325601	5.65714494	27.56636496	0.00000000
SCALLORN	3.35687615	7.08850510	30.79129360	1.93424930	24.18601102	2.98720932
ANGOSTURA	45.46342072	54.71515286	59.00103035	34.43941562	64.63116056	49.32511652
EDGEWOOD	6.56582800	11.62171722	21.66047640	1.60809252	18.26408749	5.78543488
DARL	8.34731640	13.86564290	42.85336086	4.15054559	39.39594735	11.99700479
CARROLTON	21.90614169	32.85433467	29.50655892	12.85708538	37.45955369	26.77710541
BULLVERDE	30.89885374	40.20330386	18.82160176	17.55140007	23.11663732	29.81280425
LANGTRY	24.99346609	34.31382894	35.96435405	17.18386840	45.18835825	30.02586451
NOLAN	23.48418177	36.95284596	38.24266305	14.76899841	43.96354597	29.62977072
PAISANO	6.12693286	7.16986767	42.62549014	4.78572380	40.22827421	8.27528935
PALMILLAS	6.66703594	16.27476999	21.78573437	2.33516915	23.27877463	9.33212051
PANDALE	19.97249271	27.44968277	45.78754200	13.42043754	47.61999117	24.39046875
PEDERNALES	34.06416246	35.04408010	32.54914809	20.90101194	34.66429230	31.32278656
UVALDE	9.95784107	16.10842747	16.17314004	2.23402053	15.71218183	9.28234509

Table 15.5. (continued)

$$D^2(I|J) = (\bar{X}_I - \bar{X}_J)' \, COV^{-1} \, (\bar{X}_I - \bar{X}_J)$$

GENERALIZED SQUARED DISTANCE TO TYPE

FROM TYPE	SCALLORN	ANGOSTURA	EDGEWOOD	DARL	CARROLTON	BULLVERDE
JAY	45.02013153	7.75776386	35.72890850	22.88080617	9.23045260	16.61044947
BAJADA	28.15925744	9.39181110	22.96489281	9.95969572	9.56724068	14.00926955
SAN JOSE	12.25389297	20.80986263	10.16562828	2.93925420	11.59957014	17.42466498
ARMIJO	4.43265482	29.29493486	4.41453872	4.55116193	17.38929730	25.74295472
EN MEDIO	2.12167237	38.31873054	1.77459097	7.90480285	17.08318336	18.48216036
AUGUSTIN	12.89245507	30.85290099	10.37273484	7.59464507	9.09416338	23.25637876
SAN PEDRO	3.35687615	45.46342072	6.56582800	8.34731640	21.90614169	30.89885374
CHIRICAHUA	7.08850510	54.71515286	11.62171722	13.86564290	32.85433467	40.20330386
SHUMLA	30.79129360	59.00103035	21.66047640	42.85336086	29.50655892	18.82160176
ELLIS	1.93424930	34.43941562	1.60809252	4.15054559	12.85708538	17.55140007
MARCOS	24.18601102	64.63116056	18.26408749	39.39594735	37.45955369	23.11663732
ENSOR	2.98720932	49.32511652	5.78543488	11.99700479	26.77710541	29.81280425
SCALLORN	0.00000000	45.95474498	2.46811655	7.10367285	22.69734784	26.62691084
ANGOSTURA	45.95474498	0.00000000	36.70336982	23.15200599	13.53757260	20.15993820
EDGEWOOD	2.46811655	36.70336982	0.00000000	6.33243626	13.78830239	16.54645663
DARL	7.10367285	23.15200599	6.33243626	0.00000000	11.38271302	20.07838401
CARROLTON	22.69734784	13.53757260	13.78830239	11.38271302	0.00000000	5.86324804
BULLVERDE	26.62691084	20.15993820	16.54645663	20.07838401	5.86324804	0.00000000
LANGTRY	27.24886039	10.73627999	18.16118364	13.81610870	0.85981429	7.60549455
NOLAN	25.19744228	8.42034427	17.58053466	10.31083070	2.48028593	9.89913606
PAISANO	5.55004121	31.91894583	5.42579716	2.77908616	16.02525934	26.60165462
PALMILLAS	5.80407633	29.45762414	2.54320137	6.91384086	8.85787513	15.64620158
PANDALE	20.71878817	7.80459436	14.64211713	5.65421740	4.58269355	12.66335609
PEDERNALES	28.60119511	22.40316120	21.91961606	19.26121947	13.32090349	7.63246670
UVALDE	5.40895340	29.19825161	1.38245419	7.02560683	8.69530632	9.62989295

$$D^2(I|J) = (\bar{X}_I - \bar{X}_J)' \, COV^{-1} \, (\bar{X}_I - \bar{X}_J)$$

GENERALIZED SQUARED DISTANCE TO TYPE

FROM TYPE	PAISANO	LANGTRY	NOLAN	PALMILLAS	PANDALE	PEDERNALES	UVALDE
JAY	34.72181329	7.75327768	4.42644785	27.03580145	7.68175136	26.11183461	29.30047167
BAJADA	17.33164548	8.20565415	7.66275755	22.21982784	3.24082878	9.82314027	18.44493766
SAN JOSE	4.54437460	12.60871582	12.93680527	12.63257955	6.45631174	9.84446935	8.48504057
ARMIJO	2.10750576	19.50609953	18.06847728	5.13752126	12.18357164	26.14091463	6.35307271
EN MEDIO	8.69460189	22.05250047	18.35517266	3.26346325	17.54146282	24.98219794	3.09373825
AUGUSTIN	9.99172347	12.08306170	10.04043297	4.63411153	11.21337038	32.79147821	10.41574454
SAN PEDRO	6.12693286	24.99346609	23.48418177	6.66703594	19.97249271	34.06416246	9.95784107
CHIRICAHUA	7.16986767	34.31382894	36.95284596	16.27476999	27.44968277	35.04408010	16.10842747
SHUMLA	42.62549014	35.96435405	38.24266305	21 78573437	45.78754200	32.54914809	16.17314004
ELLIS	4.78572380	17.18386840	14.76899841	2.33516915	13.42043754	20.90101194	2.23402053
MARCOS	40.22827421	45.18835825	43.96354597	23.27877463	47.61999117	34.66429230	15.71218183
ENSOR	8.27528935	30.02586451	29.62977072	9.33212051	24.39046875	31.32278656	9.28234509
SCALLORN	5.55004121	27.24886039	25.19744228	5.80407633	20.71878817	28.60119511	5.40895340
ANGOSTURA	31.91894583	10.73627999	8.42034427	29.45762414	7.80459436	22.40316120	29.19825161
EDGEWOOD	5.42579716	18.16118364	17.58053466	2.54320137	14.64211713	21.91961606	1.38245419
DARL	2.77908616	13.81610870	10.31083070	6.91384086	5.65421740	19.26121947	7.02560683
CARROLTON	16.02525934	0.85981429	2.48028593	8.85787513	4.58269355	13.32090349	8.69530632
BULLVERDE	26.60165462	7.60549455	9.89913606	15.64620158	12.66335609	7.63246670	9.62989295
LANGTRY	17.93333706	0.00000000	3.47798562	12.50923222	4.32549683	13.39584153	12.34541753
NOLAN	18.31774003	3.47798562	0.00000000	11.13285062	2.89314178	18.10576378	12.92021259
PAISANO	0.00000000	17.93333706	18.31774003	7.18388117	11.15816511	23.38996074	7.44752397
PALMILLAS	7.18388117	12.50923222	11.13285062	0.00000000	11.64334096	25.01535451	2.51151340
PANDALE	11.15816511	4.32549683	2.89314178	11.64334096	0.00000000	15.31426528	11.82134705
PEDERNALES	23.38996074	13.39584153	18.10576378	25.01535451	15.31426528	0.00000000	14.37622123
UVALDE	7.44752397	12.34541753	12 92021259	2.51151340	11.82134705	14.37622123	0.00000000

The reclassified points can be divided into five groups based on morphological similarities and general squared distance calculations. Group I is the largest, consisting of the Trans-Pecos types (Uvalde, Palmillas, Edgewood, Scallorn, Ensor, Ellis), and the Oshara types (Armijo and En Medio), and the Cochise type (San Pedro). All of these types have some overall morphological similarities and all have slightly concave to straight bases with expanding stems. Two other similarities are the acute angles that describe the proximal end-stem intersection and the notch—both of which appear to be around 45 degrees. Points within Group I were either correctly classified or reclassified into another member of the group 76 percent of the time.

Group II comprises three types: Darl, Paisano, and San Jose. All of these types have a concave base, expanding stem, some degree of side notching, and pronounced ears or basal corners. Group II points were either correctly classified or reclassified within the group 82 percent of the time. One distinguishing factor is the presence of serration along the blade edges of both Paisano and San Jose points, a trait that can be used to distinguish these points from Darl points.

Group III also contains three point types: Chiricahua, San Pedro, and Ensor. The types in this group exhibit relatively small bases with expanding stems and notches characterized by an acute angle. The major distinguishing factor is the presence of a concave base on only the Chiricahua point type. Since A1, the angle along the proximal portion of the base, has the highest discriminating value, this grouping is puzzling. This trend does seem to be prevalent, however, as noted in O'Hara and Elyea (1985). Members of this group were correctly classified or reclassified 72 percent of the time.

Group IV contains only two types: Shumla and Marcos. Both have deep basal notches and are relatively large. It appears that one major problem with the subjective classification of these two points is the degree to which large basal notch points with expanding bases are included in the Shumla class. The Shumla class reflects a great deal of variability with respect to morphology and size (Suhm and Jelks 1962). This may be one factor that explains the inability of the model to distinguish between these types. Points within this group were either correctly identified or interchangeably reclassified 88 percent of the time. Marcos points were identified correctly in all instances.

The remainder of the reclassifications, as mentioned earlier, revolve around the problem of consistent subjective typologies. Some types are very consistent, while others exhibit a large amount of variability. One major factor in the elimination of this problem may be to increase substantially the numbers in each control type. Further modification of types will therefore focus increasingly on statistical redefinition and perhaps the addition of new variables to "fine tune" the morphological descriptions.

The final stage of the analysis was the classification of the unknown hafted bifaces. Each of the Border Star 85 specimens was assigned a value derived from the following multivariate linear model, where α is a constant and β_n is the value for each discriminant function (Blalock 1979:452).

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k$$

This formula was used to define the control groups. The "DISCRIM" procedure compares the value for each unknown hafted biface to the centroid values of all of the control types. The discriminant function values for the control group centroids are presented in Table 15.6. Assignments are made based on mathematical similarities. The strength of the classifications is then reflected in the measures of posterior probability of membership. Since some of the membership probabilities for unknown items listed for each type class were similar, it was possible that incorrect classifications were made. Therefore, the bifaces were inspected in an effort to eliminate any obvious misclassifications.

All of the unknown Border Star 85 points were placed into types generated during the discriminant analysis classification. Each type corresponded to one of the control typological classes. The classified points were then visually (subjectively) compared to the actual control data set. The purpose of this exercise was to monitor the consistency of the computer classification in comparison with the more subjective typologies. A total of 117 (62 percent) of the Border Star 85 hafted bifaces were judged to be correctly classified. Seventy of the unknown Border Star 85 points (37 percent) were determined to have been incorrectly classified. These latter were reclassified according to a subjective typology designed by Janette Elyea. Reclassification occurred most frequently in the more loosely defined types and between those types that are morphologically similar. Table 15.7 is a list of the final type assignments for the Border Star 85 hafted bifaces. This list includes both those items correctly identified by the computer and those items subjectively reclassified (also see Appendix 10).

The remaining 90 Border Star 85 unknown points were judged not to be characteristic of any control type used in this study, based on subjective decisions and on the measures of posterior probability of membership. These points were therefore assigned to new categories (types BS I through BS VI). The new types may be considered part of a typology characteristic of the Tularosa Basin or south-central New Mexico rather than of the areas represented by the control types. Some precedent of the need for a distinct typology for the Tularoso Basin is evident in the results of other archeological surveys from the Border Star 85 project area (Beckett 1983; Carmichael 1983). (See Table 15.8 and Appendix 10 for a list of the types specifically created for this project.) After all points were placed either in traditional or in the newly created groups, only five hafted bifaces remained as truly unknowns.

An additional discriminant analysis was performed to compare the new Border Star 85 types with the other control types. The results of this analysis include a list of linear models defining each of the new types (Table 15.9), generalized distance measurements showing the association between the original control types and the proposed Border Star 85 types, and lists of the posterior probability of membership for each example of the Border Star 85 types. By including the Border Star 85 types, this analysis resulted in discriminant functions that mathematically describe these subjectively derived classifications. While

Table 15.6. Discriminant values function for Border Star 85 control groups

CONSTANT = $-.5\ \overline{X}_J'\ COV^{-1}\ \overline{X}_J$ COEFFICIENT VECTOR = $COV^{-1}\ \overline{X}_J$

TYPE

	JAY	BAJADA	SAN JOSE	ARMIJO	EN MEDIO	AUGUSTIN	SAN PEDRO
CONSTANT	-44.35736728	-31.33895951	-17.10962719	-13.88428592	-15.10281196	-15.21889144	-13.31513752
M1	-17.35924801	-15.29840188	-12.39372282	-12.64579137	-11.77019155	-15.83230903	-18.22198508
M7	6.20377311	3.87850702	3.62299796	2.90266862	2.84982336	6.71543918	3.50593680
M5	11.05297134	7.55425512	2.85917965	-1.32713424	-11.79941632	5.76626604	-2.03786397
M4	-2.09004688	-1.21807086	2.02045344	8.43358153	15.47521194	-1.38324174	4.23589844
M3	27.93012330	27.36175559	20.79534274	18.52828386	29.91586221	12.18070767	19.87782078
A1	12.85466496	1.90039671	-2.19989319	1.45785545	5.49686315	11.11912649	5.34586848
A4	2.24251421	1.63320839	1.28004036	2.22253178	1.56273299	1.70305917	1.19764350
M8	8.44856279	9.37583813	7.63528063	9.26877060	9.28298706	5.74054460	13.11217444

	CHIRICAHUA	SHUMLA	ELLIS	MARCOS	ENSOR	SCALLORN	ANGOSTURA
CONSTANT	-16.54016583	-39.40256926	-12.15437512	-33.94792771	-16.82578000	-10.08134729	-43.96539774
M1	-21.50967019	-14.96045765	-12.44035932	-9.44914358	-18.07402431	-12.79264113	-12.41439503
M7	2.92395677	8.09287999	3.81761495	4.07266723	2.55934941	2.28035557	4.59117118
M5	-2.59102002	-28.52039093	-6.39729422	-34.07572265	-9.52139762	-9.58085521	10.44687686
M4	4.09245572	34.92264751	9.76291763	38.70047932	11.82140404	11.97290161	4.55811958
M3	20.92230338	46.82460933	23.95630478	51.43693174	28.23417182	24.77305886	25.70789043
A1	-1.79224290	6.83470149	4.47992266	4.13414061	2.05889393	2.49535152	5.77947039
A4	1.46763077	1.52753197	1.16714049	1.82496491	1.55652001	1.36362252	2.43783891
M8	16.81334270	7.44468304	8.06463098	7.37966372	14.99667325	9.71687986	6.56312084

	EDGEWOOD	DARL	CARROLTON	BULLVERDE	LANGTRY	NOLAN	PAISANO
CONSTANT	-14.51432813	-12.70401429	-29.63892056	-37.55310431	-33.60072519	-29.69758450	-11.78521949
M1	-13.53461403	-10.44960102	-18.44178894	-18.05654421	-21.41107466	-13.42197607	-14.31063871
M7	4.43175173	2.80810846	8.34260979	7.14277078	8.68465681	6.02723005	4.06489570
M5	-9.87312082	3.01575601	2.38053821	-11.05331394	5.39334069	5.59712009	2.94087621
M4	12.84329182	1.30356918	4.24940882	16.61342088	2.47136160	2.66436071	1.34907040
M3	26.80208416	18.08963081	25.42723555	43.16369381	25.05211900	24.04840061	14.06907331
A1	3.83189443	2.86408974	8.48426905	6.53403549	7.65942969	10.29136807	-0.05929921
A4	2.34866379	1.66336201	2.13963111	1.96980347	2.23186233	1.96552770	1.97687875
M8	8.20912447	6.82074870	7.04921486	8.72604637	8.72546095	5.94203918	8.80108437

	PALMILLAS	PANDALE	PEDERNALES	UVALDE
CONSTANT	-16.56719925	-26.25506814	-35.02825482	-17.96112899
M1	-14.71820266	-14.44062924	-17.24684655	-14.35499605
M7	5.67819420	4.85769412	5.60078225	5.29651160
M5	-4.80610484	7.21037135	-6.69006218	-10.02820830
M4	10.49144996	0.37866572	12.08748260	14.60223[illegible]30
M3	22.49470603	22.11962569	39.23589782	29.68346894
A1	8.08631598	5.55418236	-3.11731395	3.81534270
A4	2.10350724	2.54955564	0.62928679	1.86456475
M8	7.53971676	7.48079973	9.98554483	7.82646533

Table 15.7. Border Star 85 projectile points classified by known type and period

SAS OBS	PERIOD	TYPE	ITEMID
1	EAR ARCHAIC	JAY	044-05
2	EAR ARCHAIC	UVALDE	080-91
3	EAR ARCHAIC	UVALDE	063-01
4	EAR ARCHAIC	JAY	068-07
5	EAR ARCHAIC	UVALDE	084-01
6	EAR ARCHAIC	PANDALE	091-02
7	EAR ARCHAIC	BAJADA	095-03
8	EAR ARCHAIC	PANDALE	095-06
9	EAR ARCHAIC	BAJADA	101-03
10	EAR ARCHAIC	PANDALE	101-05
11	EAR ARCHAIC	UVALDE	103-03
12	EAR ARCHAIC	UVALDE	104-02
13	EAR ARCHAIC	PANDALE	104-06
14	EAR ARCHAIC	UVALDE	105-02
15	EAR ARCHAIC	JAY	123-01
16	EAR ARCHAIC	PANDALE	130-08
17	EAR ARCHAIC	JAY	131-01
18	EAR ARCHAIC	BAJADA	131-08
19	EAR ARCHAIC	ANGOSTURA	132-04
20	EAR ARCHAIC	BAJADA	142-04
21	EAR ARCHAIC	BAJADA	146-01
22	EAR ARCHAIC	UVALDE	146-03
23	EAR ARCHAIC	JAY	157-01
24	EAR ARCHAIC	JAY	161-03
25	EAR ARCHAIC	JAY	176-02
26	EAR ARCHAIC	PANDALE	181-03
27	EAR ARCHAIC	PANDALE	233-02
28	EAR ARCHAIC	UVALDE	236-10
29	EAR ARCHAIC	TRAVIS	239-02
30	EAR TO MID ARCHAIC	MARTINDALE	002-77
31	EAR TO MID ARCHAIC	BULLVERDE	014-06
32	EAR TO MID ARCHAIC	BULLVERDE	029-12
33	EAR TO MID ARCHAIC	LERMA	030-02
34	EAR TO MID ARCHAIC	LERMA	055-01
35	EAR TO MID ARCHAIC	LERMA	062-17
36	EAR TO MID ARCHAIC	MARTINDALE	067-08
37	EAR TO MID ARCHAIC	BULLVERDE	076-05
38	EAR TO MID ARCHAIC	LERMA	078-01
39	EAR TO MID ARCHAIC	MARTINDALE	080-02
40	EAR TO MID ARCHAIC	BULLVERDE	101-09
41	EAR TO MID ARCHAIC	MARTINDALE	144-05
42	EAR TO MID ARCHAIC	MARTINDALE	148-05
43	EAR TO MID ARCHAIC	BULLVERDE	158-01
44	EAR TO MID ARCHAIC	LERMA	209-05
45	EAR TO MID ARCHAIC	BULLVERDE	234-04
46	EAR TO MID ARCHAIC	LERMA	221-05
47	MID ARCHAIC	SAN JOSE	022-71
48	MID ARCHAIC	CHIRICAHUA	023-01
49	MID ARCHAIC	CHIRICAHUA	025-02
50	MID ARCHAIC	CHIRICAHUA	032-13
51	MID ARCHAIC	AUGUSTIN	041-14
52	MID ARCHAIC	AUGUSTIN	050-02
53	MID ARCHAIC	AUGUSTIN	063-10
54	MID ARCHAIC	CHIRICAHUA	070-11
55	MID ARCHAIC	SAN JOSE	080-09
56	MID ARCHAIC	SAN JOSE	092-71
57	MID ARCHAIC	SAN JOSE	095-08
58	MID ARCHAIC	SAN JOSE	101-18
59	MID ARCHAIC	SAN JOSE	101-22
60	MID ARCHAIC	AUGUSTIN	185-23
61	MID ARCHAIC	CHIRICAHUA	186-12
62	MID ARCHAIC	SAN JOSE	188-05
63	MID ARCHAIC	CHIRICAHUA	227-11
64	MID ARCHAIC	SAN JOSE	237-05
65	MID ARCHAIC	AUGUSTIN	242-02
66	MID TO LATE ARCHAIC	PERDIZ	005-06
67	MID TO LATE ARCHAIC	SHUMLA	014-07
68	MID TO LATE ARCHAIC	SHUMLA	014-12
69	MID TO LATE ARCHAIC	SHUMLA	019-06
70	MID TO LATE ARCHAIC	SHUMLA	025-03
71	MID TO LATE ARCHAIC	MARCOS	025-05
72	MID TO LATE ARCHAIC	CARROLTON	029-14
73	MID TO LATE ARCHAIC	MARCOS	049-04
74	MID TO LATE ARCHAIC	CARROLTON	067-06
75	MID TO LATE ARCHAIC	PERDIZ	070-02
76	MID TO LATE ARCHAIC	MARCOS	071-02
77	MID TO LATE ARCHAIC	SHUMLA	081-04
78	MID TO LATE ARCHAIC	MARCOS	092-73
79	MID TO LATE ARCHAIC	MARCOS	092-75
80	MID TO LATE ARCHAIC	SHUMLA	097-06
81	MID TO LATE ARCHAIC	MARCOS	101-14
82	MID TO LATE ARCHAIC	SHUMLA	101-21
83	MID TO LATE ARCHAIC	MARCOS	101-23
84	MID TO LATE ARCHAIC	MARCOS	102-01
85	MID TO LATE ARCHAIC	MARCOS	102-11
86	MID TO LATE ARCHAIC	MARCOS	107-05
87	MID TO LATE ARCHAIC	MARCOS	117-04
88	MID TO LATE ARCHAIC	MARCOS	121-02
89	MID TO LATE ARCHAIC	MARCOS	126-02
90	MID TO LATE ARCHAIC	PERDIZ	130-01
91	MID TO LATE ARCHAIC	SHUMLA	131-10
92	MID TO LATE ARCHAIC	PERDIZ	141-71
93	MID TO LATE ARCHAIC	SHUMLA	153-01
94	MID TO LATE ARCHAIC	PEDERNALES	154-02
95	MID TO LATE ARCHAIC	CARROLTON	155-04
96	MID TO LATE ARCHAIC	MARCOS	161-06
97	MID TO LATE ARCHAIC	MARCOS	161-09
98	MID TO LATE ARCHAIC	CARROLTON	170-09
99	MID TO LATE ARCHAIC	PEDERNALES	177-14
100	MID TO LATE ARCHAIC	MARCOS	211-04
101	MID TO LATE ARCHAIC	MARCOS	227-08
102	MID TO LATE ARCHAIC	CARROLTON	236-04
103	MID TO LATE ARCHAIC	MARCOS	238-02
104	MID TO LATE ARCHAIC	MARCOS	249-02
105	MID TO LATE ARCHAIC	MARCOS	132-02
106	MID TO LATE ARCHAIC	MARCOS	120-01
107	MID TO LATE ARCHAIC	MARCOS	999-03
108	MID TO LATE ARCHAIC	SHUMLA	111-04
109	LATE ARCHAIC	ELLIS	002-14
110	LATE ARCHAIC	BS TYPE IV	002-20
111	LATE ARCHAIC	SAN PEDRO	002-28
112	LATE ARCHAIC	BS TYPE V	006-91

Table 15.7. (continued)

SAS OBS	PERIOD	TYPE	ITEMID	SAS OBS	PERIOD	TYPE	ITEMID
113	LATE ARCHAIC	SAN PEDRO	003-02	169	LATE ARCHAIC	BS TYPE V	092-76
114	LATE ARCHAIC	ENSOR	003-04	170	LATE ARCHAIC	BS TYPE IV	095-07
115	LATE ARCHAIC	PALMILLAS	005-05	171	LATE ARCHAIC	BS TYPE IV	102-71
116	LATE ARCHAIC	BS TYPE IV	008-02	172	LATE ARCHAIC	BS TYPE V	097-04
117	LATE ARCHAIC	BS TYPE I	008-11	173	LATE ARCHAIC	ENSOR	100-03
118	LATE ARCHAIC	BS TYPE II	008-12	174	LATE ARCHAIC	BS TYPE V	101-19
119	LATE ARCHAIC	BS TYPE V	008-14	175	LATE ARCHAIC	BS TYPE V	101-20
120	LATE ARCHAIC	SAN PEDRO	012-25	176	LATE ARCHAIC	ENSOR	102-13
121	LATE ARCHAIC	BS TYPE II	015-02	177	LATE ARCHAIC	BS TYPE V	103-10
122	LATE ARCHAIC	BS TYPE V	067-71	178	LATE ARCHAIC	PAISANO	104-01
123	LATE ARCHAIC	PALMILLAS	017-07	179	LATE ARCHAIC	BS TYPE II	106-06
124	LATE ARCHAIC	ENSOR	101-91	180	LATE ARCHAIC	BS TYPE V	106-12
125	LATE ARCHAIC	BS TYPE I	017-10	181	LATE ARCHAIC	BS TYPE IV	110-03
126	LATE ARCHAIC	SAN PEDRO	019-02	182	LATE ARCHAIC	BS TYPE V	112-02
127	LATE ARCHAIC	BS TYPE IV	019-03	183	LATE ARCHAIC	BS TYPE V	113-06
128	LATE ARCHAIC	BS TYPE VI	026-03	184	LATE ARCHAIC	ELLIS	118-04
129	LATE ARCHAIC	SAN PEDRO	033-01	185	LATE ARCHAIC	BS TYPE I	121-04
130	LATE ARCHAIC	BS TYPE IV	035-01	186	LATE ARCHAIC	ELLIS	122-04
131	LATE ARCHAIC	PALMILLAS	039-01	187	LATE ARCHAIC	ELLIS	123-03
132	LATE ARCHAIC	BS TYPE I	039-04	188	LATE ARCHAIC	BS TYPE V	123-05
133	LATE ARCHAIC	BS TYPE V	040-06	189	LATE ARCHAIC	BS TYPE III	124-02
134	LATE ARCHAIC	ELLIS	041-15	190	LATE ARCHAIC	ELLIS	130-02
135	LATE ARCHAIC	PAISANO	041-71	191	LATE ARCHAIC	ELLIS	130-06
136	LATE ARCHAIC	BS TYPE IV	042-01	192	LATE ARCHAIC	BS TYPE V	131-07
137	LATE ARCHAIC	BS TYPE II	042-02	193	LATE ARCHAIC	PALMILLAS	141-01
138	LATE ARCHAIC	BS TYPE V	100-04	194	LATE ARCHAIC	BS TYPE V	141-13
139	LATE ARCHAIC	PALMILLAS	100-06	195	LATE ARCHAIC	BS TYPE II	142-01
140	LATE ARCHAIC	BS TYPE I	045-08	196	LATE ARCHAIC	DARL	142-08
141	LATE ARCHAIC	PALMILLAS	047-05	197	LATE ARCHAIC	BS TYPE I	148-01
142	LATE ARCHAIC	BS TYPE V	048-02	198	LATE ARCHAIC	ELLIS	149-01
143	LATE ARCHAIC	PALMILLAS	049-05	199	LATE ARCHAIC	PAISANO	150-05
144	LATE ARCHAIC	BS TYPE V	050-01	200	LATE ARCHAIC	PALMILLAS	154-03
145	LATE ARCHAIC	BS TYPE IV	052-15	201	LATE ARCHAIC	BS TYPE VI	155-02
146	LATE ARCHAIC	SAN PEDRO	054-04	202	LATE ARCHAIC	SAN PEDRO	155-03
147	LATE ARCHAIC	PALMILLAS	054-01	203	LATE ARCHAIC	BS TYPE I	156-02
148	LATE ARCHAIC	SAN PEDRO	056-02	204	LATE ARCHAIC	PALMILLAS	157-06
149	LATE ARCHAIC	PAISANO	060-01	205	LATE ARCHAIC	BS TYPE I	161-07
150	LATE ARCHAIC	BS TYPE V	060-04	206	LATE ARCHAIC	BS TYPE V	170-13
151	LATE ARCHAIC	BS TYPE I	061-02	207	LATE ARCHAIC	BS TYPE IV	171-03
152	LATE ARCHAIC	BS TYPE VI	062-02	208	LATE ARCHAIC	ELLIS	172-04
153	LATE ARCHAIC	PALMILLAS	062-12	209	LATE ARCHAIC	BS TYPE V	101-71
154	LATE ARCHAIC	BS TYPE I	062-13	210	LATE ARCHAIC	ELLIS	175-02
155	LATE ARCHAIC	BS TYPE V	063-04	211	LATE ARCHAIC	BS TYPE VII	176-05
156	LATE ARCHAIC	BS TYPE V	068-03	212	LATE ARCHAIC	BS TYPE IV	176-09
157	LATE ARCHAIC	SAN PEDRO	068-05	213	LATE ARCHAIC	SAN PEDRO	179-08
158	LATE ARCHAIC	ENSOR	069-02	214	LATE ARCHAIC	BS TYPE V	179-18
159	LATE ARCHAIC	SAN PEDRO	070-09	215	LATE ARCHAIC	BS TYPE VI	180-01
160	LATE ARCHAIC	BS TYPE V	073-09	216	LATE ARCHAIC	BS TYPE V	180-07
161	LATE ARCHAIC	PAISANO	075-03	217	LATE ARCHAIC	BS TYPE IV	183-04
162	LATE ARCHAIC	BS TYPE I	075-05	218	LATE ARCHAIC	BS TYPE IV	185-30
163	LATE ARCHAIC	BS TYPE II	077-05	219	LATE ARCHAIC	PAISANO	185-32
164	LATE ARCHAIC	BS TYPE I	080-01	220	LATE ARCHAIC	ELLIS	186-06
165	LATE ARCHAIC	BS TYPE IV	080-05	221	LATE ARCHAIC	BS TYPE II	186-09
166	LATE ARCHAIC	BS TYPE II	089-02	222	LATE ARCHAIC	BS TYPE I	189-02
167	LATE ARCHAIC	BS TYPE IV	091-03	223	LATE ARCHAIC	ELLIS	190-01
168	LATE ARCHAIC	BS TYPE I	092-72	224	LATE ARCHAIC	BS TYPE V	202-01

Table 15.7. (continued)

SAS OBS	PERIOD	TYPE	ITEMID
225	LATE ARCHAIC	BS TYPE I	202-02
226	LATE ARCHAIC	BS TYPE I	202-10
227	LATE ARCHAIC	BS TYPE I	203-01
228	LATE ARCHAIC	BS TYPE IV	210-05
229	LATE ARCHAIC	BS TYPE II	220-14
230	LATE ARCHAIC	BS TYPE V	220-17
231	LATE ARCHAIC	DARL	229-07
232	LATE ARCHAIC	BS TYPE IV	234-02
233	LATE ARCHAIC	SAN PEDRO	235-04
234	LATE ARCHAIC	BS TYPE I	235-06
235	LATE ARCHAIC	BS TYPE IV	236-02
236	LATE ARCHAIC	BS TYPE VI	236-09
237	LATE ARCHAIC	ENSOR	237-03
238	LATE ARCHAIC	BS TYPE IV	237-06
239	LATE ARCHAIC	BS TYPE V	237-07
240	LATE ARCHAIC	SAN PEDRO	239-04
241	LATE ARCHAIC	PALMILLAS	241-02
242	LATE ARCHAIC	ELLIS	243-71
243	LATE ARCHAIC	SAN PEDRO	246-05
244	LATE ARCHAIC	ELLIS	249-03
245	LATE ARCHAIC	ELLIS	251-10
246	LATE ARCHAIC	PALMILLAS	251-13
247	LATE ARCHAIC	PALMILLAS	251-15
248	LATE ARCHAIC	BS TYPE III	215-18
249	LATE ARCHAIC	BS TYPE I	090-71
250	LATE ARCHAIC	BS TYPE I	053-04
251	LATE ARCHAIC	BS TYPE I	104-91
252	LATE ARCHAIC	ELLIS	120-02
253	LATE TO POST ARCHAIC	SCALLORN	101-92
254	LATE TO POST ARCHAIC	SCALLORN	034-01
255	LATE TO POST ARCHAIC	EDGEWOOD	040-03
256	LATE TO POST ARCHAIC	SCALLORN	057-02
257	LATE TO POST ARCHAIC	SCALLORN	057-08
258	LATE TO POST ARCHAIC	SCALLORN	060-02
259	LATE TO POST ARCHAIC	SCALLORN	061-10
260	LATE TO POST ARCHAIC	EDGEWOOD	077-01
261	LATE TO POST ARCHAIC	SCALLORN	088-01
262	LATE TO POST ARCHAIC	EDGEWOOD	092-74
263	LATE TO POST ARCHAIC	SCALLORN	121-03
264	LATE TO POST ARCHAIC	SCALLORN	125-07
265	LATE TO POST ARCHAIC	SCALLORN	131-04
266	LATE TO POST ARCHAIC	EDGEWOOD	172-01
267	POST ARCHAIC	FRESNO	041-06
268	POST ARCHAIC	HARRELL	045-04
269	POST ARCHAIC	HARRELL	068-04
270	POST ARCHAIC	FRESNO	186-05

Table 15.8. Border Star 85 projectile points classified by type (including newly created and unknown types)

SAS OBS	ITEMID	TYPE
1	002-14	ELLIS
2	002-20	BS TYPE IV
3	002-28	SAN PEDRO
4	002-77	MARTINDALE
5	006-91	BS TYPE V
6	003-02	SAN PEDRO
7	003-04	ENSOR
8	005-05	PALMILLAS
9	005-06	PERDIZ
10	008-02	BS TYPE IV
11	008-11	BS TYPE I
12	008-12	BS TYPE II
13	008-14	BS TYPE V
14	012-25	SAN PEDRO
15	014-06	BULLVERDE
16	014-07	SHUMLA
17	014-12	SHUMLA
18	015-02	BS TYPE II
19	067-71	BS TYPE V
20	017-07	PALMILLAS
21	101-91	ENSOR
22	101-92	SCALLORN
23	017-10	BS TYPE I
24	019-02	SAN PEDRO
25	019-03	BS TYPE IV
26	019-06	SHUMLA
27	022-71	SAN JOSE
28	023-01	CHIRICAHUA
29	025-02	CHIRICAHUA
30	025-03	SHUMLA
31	025-05	MARCOS
32	026-03	BS TYPE VI
33	029-12	BULLVERDE
34	029-14	CARROLTON
35	030-02	LERMA
36	032-13	CHIRICAHUA
37	033-01	SAN PEDRO
38	034-01	SCALLORN
39	035-01	BS TYPE IV
40	039-01	PALMILLAS
41	039-04	BS TYPE I
42	040-03	EDGEWOOD
43	040-06	BS TYPE V
44	041-06	FRESNO
45	041-14	AUGUSTIN
46	041-15	ELLIS
47	041-71	PAISANO
48	042-01	BS TYPE IV
49	042-02	BS TYPE II
50	100-04	BS TYPE V
51	044-05	JAY
52	100-06	PALMILLAS
53	045-04	HARRELL
54	045-08	BS TYPE I
55	047-05	PALMILLAS
56	048-02	BS TYPE V
57	049-04	MARCOS
58	049-05	PALMILLAS
59	050-01	BS TYPE V
60	050-02	AUGUSTIN
61	067-17	UNKNOWN
62	052-15	BS TYPE IV
63	054-04	SAN PEDRO
64	054-01	PALMILLAS
65	055-01	LERMA
66	056-02	SAN PEDRO
67	057-02	SCALLORN
68	057-08	SCALLORN
69	080-91	UVALDE
70	060-01	PAISANO
71	060-02	SCALLORN
72	060-04	BS TYPE V
73	061-02	BS TYPE I
74	061-10	SCALLORN
75	062-02	BS TYPE VI
76	062-12	PALMILLAS
77	062-13	BS TYPE I
78	062-17	LERMA
79	063-01	UVALDE
80	063-04	BS TYPE V
81	063-10	AUGUSTIN
82	067-06	CARROLTON
83	067-08	MARTINDALE
84	068-03	BS TYPE V
85	068-04	HARRELL
86	068-05	SAN PEDRO
87	068-07	JAY
88	069-02	ENSOR
89	070-02	PERDIZ
90	070-09	SAN PEDRO
91	070-11	CHIRICAHUA
92	071-02	MARCOS
93	073-09	BS TYPE V
94	075-03	PAISANO
95	075-05	BS TYPE I
96	076-05	BULLVERDE
97	077-01	EDGEWOOD
98	077-01	UNKNOWN
99	077-05	BS TYPE II
100	078-01	LERMA
101	080-01	BS TYPE I
102	080-02	MARTINDALE
103	080-05	BS TYPE IV
104	080-09	SAN JOSE
105	081-04	SHUMLA
106	084-01	UVALDE
107	088-01	SCALLORN
108	089-02	BS TYPE II
109	091-03	BS TYPE IV
110	091-02	PANDALE
111	092-71	SAN JOSE
112	092-72	BS TYPE I
113	092-73	MARCOS
114	092-74	EDGEWOOD
115	092-75	MARCOS
116	092-76	BS TYPE V
117	095-03	BAJADA
118	095-06	PANDALE
119	095-07	BS TYPE IV
120	095-08	SAN JOSE
121	102-71	BS TYPE IV
122	097-04	BS TYPE V
123	097-06	SHUMLA
124	100-03	ENSOR
125	101-03	BAJADA
126	101-05	PANDALE
127	101-09	BULLVERDE
128	101-14	MARCOS
129	101-18	SAN JOSE
130	101-19	BS TYPE V
131	101-20	BS TYPE V
132	101-21	SHUMLA
133	101-22	SAN JOSE
134	101-23	MARCOS
135	102-13	ENSOR
136	102-01	MARCOS
137	102-11	MARCOS
138	103-03	UVALDE
139	103-10	BS TYPE V
140	104-01	PAISANO
141	104-02	UVALDE
142	104-05	UNKNOWN
143	104-06	PANDALE
144	105-02	UVALDE
145	106-06	BS TYPE II
146	106-12	BS TYPE V
147	107-05	MARCOS
148	110-03	BS TYPE IV
149	112-02	BS TYPE V
150	113-06	BS TYPE V
151	117-04	MARCOS
152	118-04	ELLIS
153	121-04	BS TYPE I
154	121-02	MARCOS
155	121-03	SCALLORN
156	122-04	ELLIS
157	123-01	JAY
158	123-03	ELLIS
159	123-05	BS TYPE V
160	124-02	BS TYPE III
161	125-07	SCALLORN
162	126-02	MARCOS
163	130-01	PERDIZ
164	130-02	ELLIS
165	130-06	ELLIS
166	130-08	PANDALE
167	131-01	JAY
168	131-10	SHUMLA

Table15.8. (continued)

SAS OBS	ITEMID	TYPE
169	131-04	SCALLORN
170	131-07	BS TYPE V
171	131-08	BAJADA
172	132-04	ANGOSTURA
173	141-71	PERDIZ
174	141-01	PALMILLAS
175	141-13	BS TYPE V
176	142-01	BS TYPE II
177	142-04	BAJADA
178	142-08	DARL
179	144-05	MARTINDALE
180	146-01	BAJADA
181	146-03	UVALDE
182	148-01	BS TYPE I
183	148-05	MARTINDALE
184	149-01	ELLIS
185	150-05	PAISANO
186	153-01	SHUMLA
187	154-02	PEDERNALES
188	154-03	PALMILLAS
189	155-02	BS TYPE VI
190	155-03	SAN PEDRO
191	155-04	CARROLTON
192	156-02	BS TYPE I
193	157-01	JAY
194	157-06	PALMILLAS
195	158-01	BULLVERDE
196	161-03	JAY
197	161-06	MARCOS
198	161-07	BS TYPE I
199	161-09	MARCOS
200	170-09	CARROLTON
201	170-13	BS TYPE V
202	171-03	BS TYPE IV
203	172-01	EDGEWOOD
204	172-04	ELLIS
205	101-71	BS TYPE V
206	175-02	ELLIS
207	176-02	JAY
208	176-05	BS TYPE VII
209	176-09	BS TYPE IV
210	177-14	PEDERNALES
211	179-08	SAN PEDRO
212	179-18	BS TYPE V
213	180-01	BS TYPE VI
214	180-07	BS TYPE V
215	181-03	PANDALE
216	183-03	UNKNOWN
217	183-04	BS TYPE IV
218	185-23	AUGUSTIN
219	185-30	BS TYPE IV
220	185-32	PAISANO
221	186-05	FRESNO
222	186-06	ELLIS
223	186-09	BS TYPE II
224	186-12	CHIRICAHUA
225	188-05	SAN JOSE
226	189-02	BS TYPE I
227	190-01	ELLIS
228	202-01	BS TYPE V
229	202-02	BS TYPE I
230	202-10	BS TYPE I
231	203-01	BS TYPE I
232	209-05	LERMA
233	210-05	BS TYPE IV
234	211-04	MARCOS
235	220-14	BS TYPE II
236	220-17	BS TYPE V
237	227-08	MARCOS
238	227-11	CHIRICAHUA
239	229-07	DARL
240	233-02	PANDALE
241	234-02	BS TYPE IV
242	234-04	BULLVERDE
243	235-04	SAN PEDRO
244	235-06	BS TYPE I
245	236-02	BS TYPE IV
246	236-04	CARROLTON
247	236-09	BS TYPE VI
248	236-10	UVALDE
249	237-03	ENSOR
250	237-05	SAN JOSE
251	237-06	BS TYPE IV
252	237-07	BS TYPE V
253	238-02	MARCOS
254	239-02	TRAVIS
255	239-04	SAN PEDRO
256	241-02	PALMILLAS
257	242-02	AUGUSTIN
258	243-71	ELLIS
259	246-05	SAN PEDRO
260	249-02	MARCOS
261	249-03	ELLIS
262	251-10	ELLIS
263	251-13	PALMILLAS
264	251-15	PALMILLAS
265	215-18	BS TYPE III
266	132-02	MARCOS
267	120-01	MARCOS
268	221-05	LERMA
269	999-03	MARCOS
270	090-71	BS TYPE I
271	053-04	BS TYPE I
272	132-09	UNKNOWN
273	111-04	SHUMLA
274	104-91	BS TYPE I
275	120-02	ELLIS

Table 15.9. Linear discriminant functions for Border Star 85 Types I through VI

Constant	BSI	BSII	BSIII	BSIV	BSV	BSVI
M1	-7.948	-6.870	-6.451	-7.873	-10.808	-6.776
M7	-2.739	-3.489	-6.053	-1.300	-1.208	-2.906
M5	-5.044	6.719	-0.391	-8.660	-9.589	2.302
M4	5.576	6.677	-1.254	9.482	10.826	-1.775
M3	14.200	14.044	8.680	16.535	20.727	9.296
A1	4.356	1.015	3.890	3.159	3.000	5.518
A4	1.856	1.757	0.618	1.528	1.484	1.315
M8	1.798	1.775	1.461	2.258	2.006	1.542

Constant = 0.5

these results must be considered preliminary, they represent an important first step in creating a working typology for the Tularosa Basin and adjacent areas.

The discriminant analysis is still being developed as an effective research tool. This study is ambitious because it has tried to integrate a number of regional typologies in order to evaluate an area that has received a limited amount of attention. The discriminant analysis was able to model all of the control types, but it was not able to distinguish among some of them because of morphological similarities. Most of the reclassifications occurred in these groups. Morphological similarities exist among and within the types that comprise the Oshara, Trans-Pecos, and Cochise typologies. Because of this ambiguity, and because of the problems in the classifications of those hafted bifaces that are not representative of any known control group, it has been necessary to augment the computer analysis with a subjective typology. The combination of these two methods has resulted in an effective strategy for preliminary studies such as this.

Miscellaneous Points

In adopting Holmer's methodology, we have utilized a typological scheme designed to differentiate among various corner-notched and side-notched "dart point" styles from the Great Basin. The inclusion of stemmed and shouldered points can be accommodated, but some other classes of points are difficult to incorporate in a study such as this. As a result, some projectile points were not included in the discriminant analysis. It is important that these points be identified in order to present a complete discussion of Border Star 85 chronology. These hafted bifaces fall within three classes: shoulderless (encompassing many Paleoindian forms as well as some types from later periods); small, Formative period "arrow" points; and artifacts that were too fragmented for use in the discriminant analysis but could still be subjectively typed.

Eighteen shoulderless points have been identified by Janette Elyea as attributable to the Paleoindian period. Evidence of Paleoindian occupation has been identified throughout the Tularosa Basin (Beckett 1983; Broilo 1973; Weber and Agogino 1968). Little is known, however, of the extent of occupation or the function of possible Paleoindian sites. The sites usually are adjacent to large, extinct playas. Paleoindian sites are also known to exist in mountain passes around the Tularosa Basin (Beckett 1983:103). Table 15.10 lists all examples of Paleoindian projectile points collected during Phase I.

Other shoulderless points were also unsuitable for inclusion in the discriminant analysis. These types are usually represented by just a few examples and have relatively distinct morphologies. Examples of shoulderless points found during Phase I have been assigned to either the Lerma/Pelona or Fresno types. These are also listed in Table 15.7 (and included in Appendix 10).

The second class of hafted bifaces not included in this discriminant analysis includes those commonly referred to as arrow points. These artifacts are common in the post-Archaic periods, and the class has been divided into several types. Since these points exhibit a wide range of morphological variability, it was difficult to describe them properly with the methodology used for the rest of the hafted bifaces. Harrell, Perdiz, Bonham, and Toyah types have been identified in the Border Star 85 area. Examples of these post-Archaic types are listed in Table 15.7 (and also Appendix 10).

Table 15.10. Paleoindian hafted bifaces collected during the Border Star 85 Phase I survey

Item ID	Type
69-04	Folsom
148-82	Folsom
180-10	Folsom
180-05	Folsom
180-04	Midland
13-02	Plainview
51-01	Plainview
60-03	Plainview
174-07	Plainview
176-07	Eden
233-05	Paleo—Unknown Type I
233-03	Paleo—Unknown Type I
19-05	Paleo—Unknown Type II
128-01	Paleo—Unknown Type II
233-04	Paleo—Unknown Type II
227-01	Paleo—Unknown Type III
236-01	Paleo—Unknown Type III
60-01	Meserve

The remaining hafted bifaces not included in the discriminant study were too fragmented to be measured. A small number of complete points were inadvertently excluded from the study. All of these points have been classified by Janette Elyea (Table 15.11).

Chronology

As discussed earlier, one of the main objectives of this projectile point analysis is to place a study population within a general regional chronology. An assumption has been consistently made in archeology that distinct morphological types are usually attributable to a particular culture that existed within an identifiable time frame. Most archeologists realize that problems exist when regional chronologies are based on information from relatively few sites and even fewer ranges of absolute dates. Even though this practice presents numerous problems of comparability, it is usually the only alternative if one wants to establish some time frame for the artifacts from a given study area.

Numerous publications from the Cochise, Oshara, and Trans-Pecos areas were consulted in order to establish a basis for creating a chronology for the Border Star 85 study area. General time frames referred to as Early Archaic, Middle Archaic, Late Archaic, Middle to Late Archaic and post-Archaic were created based on known radiocarbon dates or interpolations from relative chronologies established for each hafted biface type class. Table 15.7 lists each of the major chronological periods and type classes and their individual artifacts (collected during Phase I).

Table 15.11. Typological classification of hafted bifaces

Item ID	Type	Period
5-07	Shumla	Middle to Late Archaic
11-61	Shumla	Middle to Late Archaic
12-20	Ensor	Late Archaic
31-03	Marcos	Late Archaic
40-01	Shumla	Middle to Late Archaic
45-02	Ellis	Late Archaic
50-06	Bullverde	Middle to Late Archaic
69-01	Bonham	Post-Archaic
68-15	Ellis	Late Archaic
91-01	Lerma	Middle Archaic
76-08	BS Type IV	Late Archaic (?)
114-01	Lerma	Middle Archaic
123-09	Jay	Early Archaic
109-91	Bonham	Post-Archaic
141-72	Shumla	Middle to Late Archaic
144-02	BS Type II	Late Archaic (?)
151-02	Bonham	Post-Archaic
158-71	Shumla	Middle to Late Archaic
175-04	Marcos	Late Archaic
183-02	Marcos	Late Archaic
208-08	Jay	Early Archaic
252-01	Martindale	Middle Archaic

Note: All specimens listed were considered too fragmentary for or inadvertently excluded from discriminant analysis.

One important question to ask about the discriminant analysis is how the mathematical identification of morphological types affects the chronological interpretation. The most dramatic impact would be related to reclassification. For example, if the chronology were strictly based on the results of the discriminant analysis performed in the present study, the chronological estimates would be correct in 76 percent of the classes, based on the reclassification groups.

Group I, the largest reclassification category, contained nine type classes. The similarities that led to the occurrence of reclassification centered on the shape of the stem and proximal portions, and to some degree on the shape and angle of the notch. Seven of these points date to the Late Archaic, including the terminal Late Archaic and/or post-Archaic. Only Uvalde, an Early Archaic type, and San Jose, a Middle Archaic type, are from substantially different time periods.

Group II is made up of Darl, Paisano, and San Jose types, which are morphologically very similar. While the Darl and Paisano types occur during the latter part of the Late Archaic, San Jose types have been dated to the Middle Archaic.

Group III is composed of Chiricahua, San Pedro, and Ensor types. The San Pedro and Ensor types have roughly identical time frames, while the Chiricahua type occurs earlier, in the Middle Archaic. These types may overlap, however, as accurate dates are still not available (see Beckett 1973; Sayles 1983).

Group IV includes the Marcos and Shumla types. Both of these types occur from the late Middle Archaic into the Late Archaic.

To date most studies have emphasized the relationship of form to a mental template, thereby enabling chronologies to be established for the cultural phases represented by specific point types. The degree to which changes in morphology are related to general changes in technology across long spans of time is not frequently explored. Several trends are apparent in the Border Star 85 Phase I data that may be viewed as technological changes, however (Roney 1985:22). The first stage is marked by shoulderless Paleoindian forms. The second is characterized by straight to slightly contracting large stemmed points (Pandale, Travis, Angostura, Bajada, Jay, and Meserve). A third stage consists of large straight or expanding corner-notched and basal-notched points (Martindale, Pedernales, Bullverde, Marcos, Shumla, and San Jose). This stage appears to overlap with the fourth stage, which represents most of the Late Archaic and is composed of expanding side- or corner-notched hafted bifaces with predominately convex bases (Ansor, Ellis, Palmillas, San Pedro, Edgewood, En Medio, and Scallorn). The relatively high degree of variability in the fourth stage is consistent with the "broad spectrum" hypothesis of later Archaic exploitation strategies. The proposed Border Star 85 point types fit well into this fourth category. The fifth and final stage is marked by the absence of large and medium points characteristic of stages three and four and by the appearance of small arrow points, indicative of the ceramic periods.

The distinguishing elements of these hafted bifaces are not totally characteristic of all forms assigned to a particular stage, e.g., such points as Carrolton, Paisano, and Darl are also characteristic of much earlier types. Despite these and other anomalies, strong temporal trends do exist (Roney 1985). One direction that could be taken to better distinguish between functional and stylistic change might be the study of the variations of associated lithic, faunal, and floral assemblages.

Summary

At the beginning of this chapter it was noted that two strategies can be used to create hafted biface typologies. This study has tried to integrate both strategies to establish a workable classification for the Border Star 85 Phase I collections. The use of discriminant analysis to create mathematical models and objectively classify hafted bifaces was explored. When judged subjectively, the results did not provide us with a completely satisfactory classification system. In combination with a subjectively derived typology, however, the results can be better understood and the resulting typology made more acceptable.

One result of the study has been an evaluation both of the change in point morphology through time and of the high degree of variability in the classification of point types. Strong trends in associated morphological changes through time resulted in the recognition of several categories of projectile points that frequently were interchangeably reclassified during the discriminant analysis. Other problems with the discriminant classification of types is the presence of a much higher degree of variation in subjective types than was expected. Reclassification between types with larger pair-wise squared generalized distances between groups was frequent because of this problem. Holmer's (1978) initial assumptions about sample size (minimum of eight specimens per type) is based on a much lower range of variability within type classes. It is obvious that each control group will need to be re-evaluated based on the results of the discriminant analysis. Once large numbers of each type are included in a study, typological reclassification based on the statistical results should be made. In conjunction with the definition of previously unidentified types, this reclassification will be an on-going process whose ultimate goal will be a workable, objectively derived typology.

Chapter 16

FORMAL LITHIC TOOL ANALYSIS

Jeanne A. Schutt

Introduction

The formal tool analysis undertaken for artifacts recovered from the Border Star 85 study area was designed primarily to maximize information about tool function and to determine whether formal tools represent the results of manufacturing activities or the results of tool use. The formal tools examined in this study are non-projectile point bifaces, unifaces, and marginally retouched artifacts. Facially and marginally retouched tools were examined to address three questions:

1) do tools represent manufacturing failures or do they represent use activities carried out at sites,
2) what were the tools used for, and
3) what stage of manufacture do bifacial tools represent?

A discussion of the projectile points recovered from the study area can be found in Chapter 15.

The following analysis is based on two formal tool studies conducted over the past five years (Schutt 1983:263–268; Schutt and Vierra 1980:53–54). These studies were aimed toward determining sequences of tool manufacture and discard as well as identifying tool function when use-wear could not be identified.

Formal tools that are recovered archeologically represent varied stages of manufacture and use. It has often been assumed that formal tools recovered from archeological contexts represent utilized tools that were discarded because they were no longer functional. These artifacts are then interpreted as representing functional variability and, in conjunction with other data, are used to assign behavioral meaning to sites they were found in. A close examination of formal tool morphology indicates that many formal tools in fact represent manufacturing failures, which were never used. These artifacts were broken during manufacture, not completed due to flaws in the material, or not completed due to errors in the reduction process. Generally these manufacturing failures occur archeologically at the location of manufacture, thus providing valued information on the location and form of tool manufacture, but little information about the associated functional tool use activities. When formal artifacts that are actually manufacturing failures are reported as representing utilized tools (rather than discards from formal tool manufacture) interpretations of activities performed and assessments of site type are skewed tremendously.

This study examines the use of edge angle variability as an objective criterion for distinguishing between tools that were used and discarded (complete tools) and manufacturing failures (incomplete tools). Previous analyses conducted by the author indicate that the range of edge angle variability on the functional edges of formal tools can be employed, with a high degree of success, to distinguish objectively between complete and incomplete tools (Schutt 1983). Additionally, a large proportion of formal tools found in assemblages cannot be assigned to functional categories. These tools exhibit neither identifiable wear patterns indicating how they were used nor a morphology suggestive of tool function. The present study is also aimed toward functionally classifying these tools. Information on tool function can then be used to determine the activities that were carried out prehistorically.

The function for which a tool can be used is conditioned by the edge shape of the utilized portion of the tool (Wilmsen 1968). Both facial and marginal retouch represent an attempt to change the edge shape of the tool to meet certain requirements. These requirements are conditioned by the activity that will be performed with the tool. Analyses of utilized tools recovered from archeological assemblages (Schutt 1983) indicate that scraping tools with unidirectional wear patterns exhibit steeper edge angles, while cutting tools with bidirectional wear exhibit more acute edge angles.

In addition to possessing an edge shape dictated by a particular activity, a functional edge must also exhibit a uniform edge morphology, regardless of tool type. The various functions for which a tool is used may require a variety of functional edge shapes and lengths, but all activities require that the tool has a uniform functional edge to perform the task effectively. The functional requirement of a cutting tool is a sharp, uniform edge. The edge of the knife may be straight or serrated, but it must form a uniform straight line in plan view. The same is true of scraping tools. Although they are used functionally to perform different activities (cutting vs scraping), a uniform edge is still necessary. Whereas the cutting tool requires a uniform sharp edge, the scraping tool requires a uniform edge that is not acute and that will withstand the force necessary for scraping activities. Projectile points require a point and two uniform lateral edges to facilitate piercing. Although overall tool morphology is different, the functional edges are all uniform.

A major problem in previous analyses has been the subjective rather than objective nature of classification. Thus, a number of subjective criteria have been used, including the presence of a transverse and laterally uniform functional edge, to identify functionally usable tools. Edges are subjectively classified as uniform, on the basis of the lateral and transverse line formed by retouching, and are classified independently of edge angle. Manufacturing failures have been subjectively classified as exhibiting breakage, flaws within the materials, or errors in knapping that

prevent further reduction. Other subjective criteria used to distinguish these artifacts are variables that reflect overall symmetry, including edge uniformity, bifacial thinning, pressure retouch, thickness, and overall workmanship. All of these criteria must be used collectively when classifying artifacts subjectively; thus the classifications are not objectively comparable from one analyst to another.

In order to address the problem of subjectivity in analysis, the author has argued that completeness of a functional edge is considered to be an important variable in determining the use potential of a tool (Schutt 1983). Consequently, it would be instructive to develop an objective measure of this variable rather than to rely on subjective criteria. Edge angle variability of a functional edge has been shown to be an objective indicator of edge uniformity and, therefore, of a functionally complete versus functionally incomplete edge (Schutt 1983). This study has also shown that tools with edges identified by subjective criteria as functionally complete have less variability in edge angle than do those with edges identified as functionally incomplete. Edges with a range of angles greater then 15 degrees were consistently those previously designated (subjectively) as functionally incomplete, while those with a range of edge angles of less than 15 degrees were the ones subjectively defined as functionally complete.

The range of edge angle variability on a functional edge is thus argued to be a valid measure of edge completeness or incompleteness. Based on such variability, one can objectively assign functional edges to the same classes previously only identified by subjective methods. The measurement of the range can be used as a single objective criterion to distinguish between manufacturing failures or functionally incomplete tools and those that were potentially used and discarded. In using an objective criterion, consistent analysis can be repeated by different observers.

Retouched artifacts recovered from the Border Star 85 project were classified as functionally incomplete (manufacturing failures) or functionally complete (tools) to facilitate the determination of whether the range of edge angles on functional edges could be used to objectively reclassify the same tools. Bifacially manufactured artifacts were further classified to provide information on stages of tool manufacture (Schutt 1983). Four classes of bifacial manufacture representing different stages in the manufacturing process were monitored. By identifying these stages, it is possible to determine the stage of manufacture at which a tool enters the archeological record. These data can then be used to develop expectations for varied artifact content and to interpret archeological assemblages.

A total of 670 formal tools collected during the Border Star 85 project are included in the analysis reported here. This total represents the formal tools collected during Phase I of the survey and the 121 artifacts collected during Phase II from a Paleoindian site (LA 63880) and reported in Chapter 17. Fifteen Paleoindian tools recovered during Phase I from LA 63880 are included in both assemblages; thus the Phase I assemblage actually totals 564 artifacts.

Attributes Monitored

The attribute analysis was divided into two stages in order to eliminate potential biases in recording edge angles on complete and incomplete tools: (a) tool measurements and edge angle measurements on functional edges were recorded by a technician; (b) all other attributes were monitored by the author. The following attributes were recorded: material type, portion, size, edge angle, and tool type.

Material Type

Formal tool material types were identified in the laboratory using the four-digit classification developed by A. H. Warren (1967, 1977, 1979). To maintain consistency, the recovered specimens were sorted by material and then examined by by A. H. Warren.

The majority of material types identified in the formal tool assemblage occur in the Jarilla Mountains in the eastern portion of the study area. A number of other materials are found in the Organ, San Andres, and Sacramento mountains that border the Tularosa Basin. A few artifacts were manufactured from basalt occurring in the Carrizozo lava flows to the north.

Although this paper addresses some aspects of technology as it relates to material selection, a more detailed discussion of raw material sources can be found in Appendix 4.

Portion

Tools were identified as either whole or fragmentary. A tool was considered a fragment if any portion was missing. This attribute should not be confused with "completeness," which is described below.

Size

Size was recorded by measuring the length, width, and thickness to the nearest millimeter. The length represents the longest dimension from proximal to distal. The width is the greatest measurement at 90 degrees to the length, and thickness is the greatest measurement of the third dimension of the artifact. When the proximal-distal axis of the artifact can not be identified, the length represents the longest axis of the artifact.

Measurements were used to describe overall artifact size. In addition, ratios of length to thickness [illegible]mined to determine if this ratio might also be used [illegible]guish between complete and incomplete tools.

Edge Angle

Edge angle measurements were made at several points along the perimeter of the functional edges. For the purpose of this study edge angle measurements are defined as the measurement at the intersection of dorsal and ventral surfaces, not the angle resulting from utilization. Tringham et al. (1974) define this angle as the spine-plane angle.

A number of edge angle measurements (up to eight per

edge) were taken along each functional edge identified. Functional edges are defined by the overall shape of the tool. For example, measurements on a preform, exhibiting no discrete functional edges, would be taken around the entire perimeter of the artifact. Measurements on a drill would be taken along both cutting edges of the drill shaft. Both sides of the shaft would be considered one functional edge. When retouch or overall edge morphology dictated that two functional edges may be present, several measurements were taken along each functional edge. For example, a bifacial knife may have a cutting edge as well as a backed edge to facilitate holding the implement. The functional requirements of these two edges are different so two sets of edge angle measurements must be recorded.

Tool Type

All formal tools were initially assigned to a tool type category. The majority fell into three categories: biface, uniface, or marginally retouched artifacts. Additional categories included biface/projectile point, biface/drill, perforator, and graver. This initial tool type classification was used in conjunction with other attributes to assign final tool types.

Complete/Incomplete Classification

Artifacts were subjectively classified by the author as either complete, incomplete, or undetermined. Tools were classified on the basis of overall symmetry, consistency of shape, retouch, thinning, and type of retouch, as well as inconsistencies or problems with raw materials, visible errors in tool manufacture, and general morphological inconsistencies. With minimal flint knapping experience it is possible to identify flaws in the raw material or knapping errors that prevented further reduction of the tool. Breakage resulting from these inconsistencies can also be readily identified. Edge angle was not used to classify tools subjectively according to the completeness criteria.

Other morphological attributes, characteristic of specific tool types, can also be used to distinguish between complete and incomplete tools. For example, one of the last steps in projectile point manufacture is basal grinding or notching. The presence of these attributes may indicate that the tool is complete.

The presence of use-wear may also indicate that the tool is complete, however, its absence does not necessarily suggest that the tool is incomplete. The problems in the identification of use-wear on retouched artifacts, using low power magnification, have been well documented (Keeley 1974; Odell 1975; Schutt 1980). Additionally, one must be cautious when using wear patterns to classify tools as complete for secondary reuse of incomplete tools may have occurred as well.

The subjective classification of formal tools as complete or incomplete must rely on all of the above criteria. No single observed attribute can be used to make this classification.

Utilization

All artifacts were scanned routinely for use-wear under 20x optical magnification; however, when necessary, up to 80x magnification was used. A Swift binocular microscope was used to examine each artifact.

Five categories of use-wear were identified in this study. These categories include unidirectional hard, unidirectional soft, bidirectional, battering, and boring/drilling. These use-wear classifications were based on micro-wear patterns described by Chapman and Schutt (1977). The classification of unidirectional and bidirectional wear was based on a study conducted by the author, which indicates that scraping tools exhibit dorsal/ventral edge scar ratios greater than 3.5:1, while cutting tools have scar ratios less than or equal to 3.5:1 (Schutt 1982:94–118).

An earlier experimental study also indicates that bone and wood working are activities that produce wear patterns identifiable through the use of low power techniques of magnification (Schutt 1980:80). A number of other activities do not produce identifiable wear patterns. The identification of hard and soft scraping wear was also based on hide tanning experiments conducted by the author. These experiments indicate that rounding of the shoulders of the flake edge as well as unidirectional rounding can result from scraping on hides (Schutt 1980:74). These rounded shoulders do not result from scraping on hard materials such as bone and wood.

Comments

A comments code was used (a) to identify tools that were reworked, exhibited evidence of secondary use, or were unusual, and (b) to distinguish between edges that were manufactured for use versus backing. The identification of use edges versus backed edges is critical to this study. The distinction was maintained because the edge angle variability requirements of a functional edge are very different from those of an edge manufactured for backing.

Computer-generated Attributes

A number of tool classifications were generated by combining various attributes identified during initial artifact recording.

Mean Utilized Edge Angle

Several edge angle measurements were taken along edges that exhibited use-wear. The mean was calculated for the edge angle measurements taken along utilized edges. The identification of edges with unidirectional and bidirectional wear in conjunction with their mean utilized edge angles was used to plot frequency histograms that were later used to assign functional classes to complete artifacts that exhibited no evidence of utilization.

Final Tool Type

The final tool classification also combined attributes monitored during the initial tool examination. Attributes of the initial tool type and utilization categories were combined to identify knives and scrapers. For example, a tool

that was identified as a biface with bidirectional wear patterns would be reclassified as a *bifacial knife*. Similarly, a tool that was initially identified as a biface with unidirectional wear was reclassified as *bifacial scraper*. The same procedure applies to unifaces and marginally retouched artifacts. If actual wear patterns are evident, the tools are classified with the prefix uniface, biface, unidirectional marginal, or bidirectional marginal, followed by the use-wear classification of knife or scraper.

Frequency histograms illustrating mean edge angle variability for scrapers and knives were then used to assign functional classifications to all complete tools that *lacked* actual evidence of wear patterns, thus increasing the number of tools with functional classifications. When the functional classification was based on frequency histograms rather than actual wear patterns, the prefix, biface, uniface, unidirectional marginal retouch, or bidirectional marginal retouch designation was followed by *probable scraper* or *probable knife* When frequency histograms could not be used to indicate functional variation, the initial tool type classification was maintained. Initial tool type classifications were also maintained among tools classified as incomplete.

Tool Subclass

An additional classification of functional variability, generated from tools exhibiting utilization, was based on the edge angles of utilized scraping tools and the edge angles among cutting tools. Frequency histograms were used to assess variability in mean edge angles within scraping tools and then within cutting tools. This method resulted in the identification of functional subclasses among scraping tools, but not among cutting tools.

The following section will describe the results of the various analyses described above.

Results of the Analysis

A number of tools exhibit multiple utilized edges; thus, although the analysis reports 670 tools, 830 tool edges are represented. In the analysis of tool function, utilized edges alone are counted, while the discussion of complete and incomplete artifacts deals with individual artifacts as well as edges. Edges from all artifacts recovered during Phase I survey equaled 670, while edges of tools recovered from a Paleoindian site (LA 63880) totaled 184. Twenty-four of the edges on Paleoindian artifacts recovered from LA 63880 were collected during Phase I survey and are included in both assemblages.

Analysis of Tool Completeness

As described in the introduction to this chapter, the goal of this analysis is to discover the degree to which edge angle variability is a useful predictor of tool completeness. Edge angle variability on tools that were subjectively classified as manufacturing failures (incomplete) or tools that were used and discarded (complete) is examined in this process. These results are then used to determine whether the range of edge angles on functional edges can be used as an objective criterion to distinguish between manufacturing failures and tools that were used.

Two principal methods were used to define this relationship. In the first, histograms plotting the range of edge angle variability on complete and incomplete tools were examined. The measure used was the range of angles present on each functional edge, that is, the difference between the largest and smallest edge angle values recorded.

The second method involves a comparison of mean edge angle variability among complete and incomplete tools using a standard one-tailed t-test. Normal probabilities are then used to determine which ranges of edge angles occur in the "overlap zone" between the two distributions. These statistical manipulations represent an improvement on the methods used in previous studies and result in fewer unclassified tools.

The results of the analyses clearly indicate that the edge angle range on formal tool edges is a valid predictor of completeness and thus is useful for distinguishing between complete and incomplete tools. Figures 16.1 and 16.2 show the edge angle range for complete versus incomplete edges for the Phase I and Paleoindian assemblages, respectively. Artifact classes represented in the histograms are bifaces, unifaces, and marginally retouched tools. From both figures it is clear that, as expected, complete tools exhibit lower overall edge angle variability and thus more uniform edges than incomplete tools.

Among the Phase I artifacts, 203 edges were initially classified as complete while 366 edges were incomplete. The Paleoindian assemblage included 94 complete and 152 incomplete edges.

A one-tailed t-test comparing the difference between the mean edge angle ranges of the two categories indicates significance at the .0001 confidence level for both assemblages. Prior to the calculations, outliers (values violating the normality assumption) were identified by inspection of box plots and were eliminated. A one-tailed test was used since the directionality of the difference has been predicted (complete $<$ incomplete). Table 16.1 contains the

Table 16.1. t-test for Phase I and Paleoindian tool edge angle range vs completeness

	Complete		Incomplete				
Assemblage	Mean	95 Percent CI	Mean	95 Percent CI	t	p ($>t$)	N
Phase I	10.22	0.76	22.41	0.92	20.04	0.0001	569
Paleoindian	11.85	1.13	21.86	1.38	10.99	0.0001	246

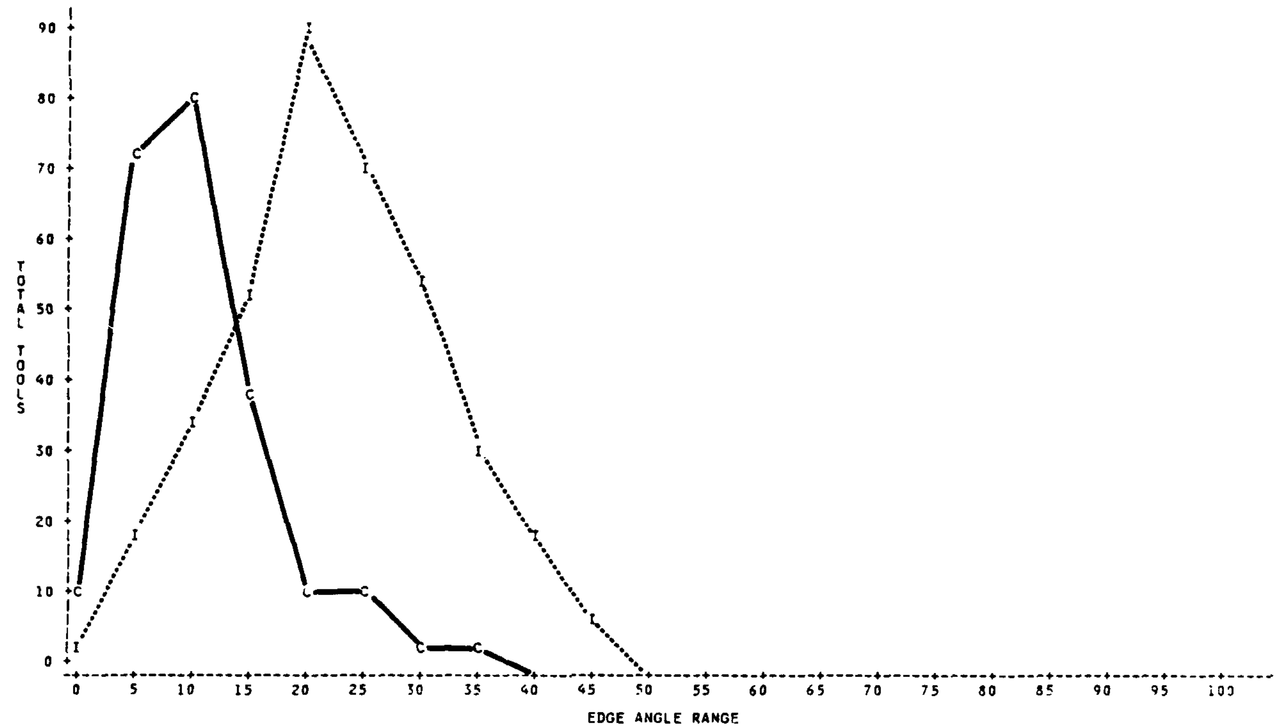


Figure 16.1. Edge angle ranges for complete (C) vs incomplete (I) tools: Phase I—all tool edges

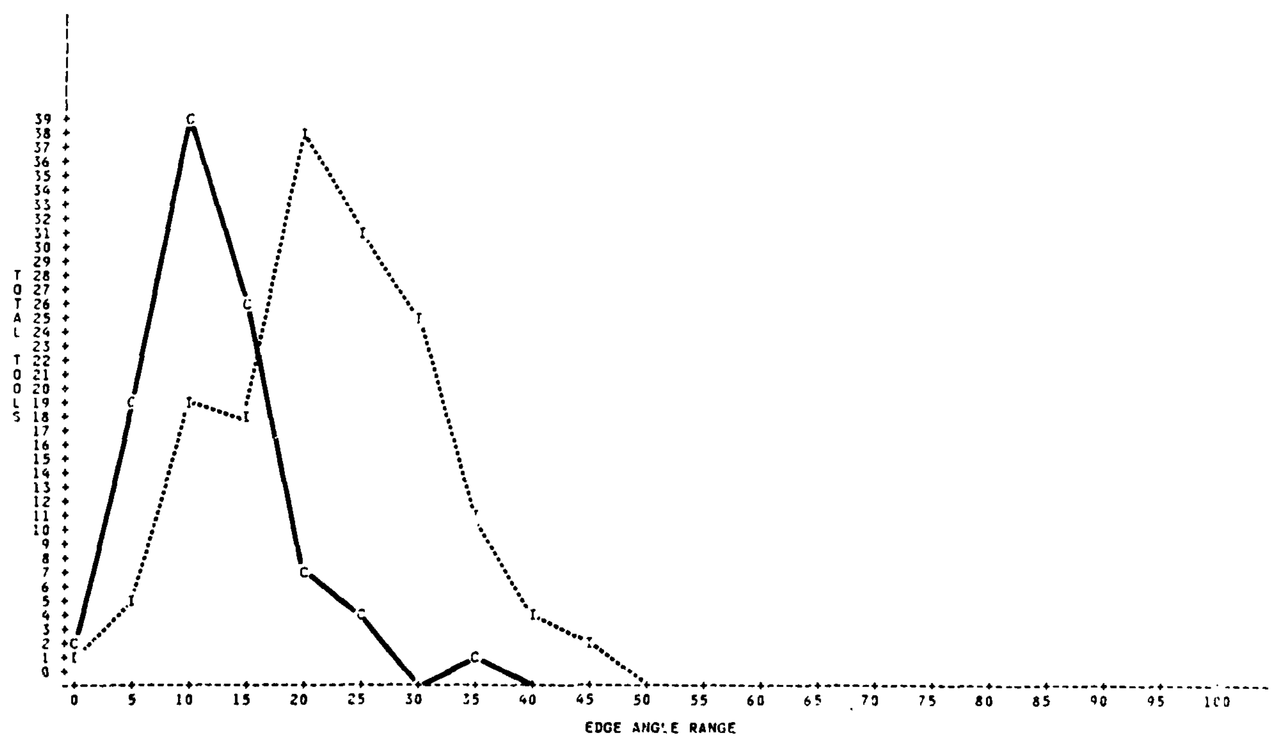


Figure 16.2. Edge angle ranges for complete (C) vs incomplete (I) tools: Paleoindian—all tool edges

t-test results for both assemblages. Included are the means and 95 percent confidence intervals for each category. The pattern is quite similar for both the Paleoindian and the Phase I artifacts. Means for complete and incomplete tool edges differ by fewer than two degrees. The smaller t statistic and larger confidence interval for the Paleoindian data may indicate greater variability or may result from the smaller sample size. These data indicate that edge angle variability can be used to distinguish between complete and incomplete formal tools.

Marginally retouched artifacts represent tools that require less time investment in tool manufacture than unifaces and bifaces. Because retouch only occurs on the perimeter of the artifact, the criteria for classifying a tool as complete are less stringent. In the classification of unifaces or bifaces, the distinction between complete and incomplete is based on overall symmetry; for marginally retouched artifacts, only the uniformity of the retouched edge can be considered.

Both the Phase I and Paleoindian assemblages produced a higher proportion of complete tools among marginally retouched artifacts than among the more formal tools. Table 16.2 shows the ratio of complete to incomplete tools by tool class for the two assemblages. In an attempt to determine whether a greater number of marginally retouched artifacts were actually completed before discard, or whether they were misclassified as a result of the difficulty of distinguishing between complete and incomplete marginally retouched tools, frequency histograms were drawn to show the distributions of edge angle range. Figure 16.3 compares complete and incomplete unifaces and bifaces from Phase I assemblage, while Figure 16.4 compares complete and incomplete marginally retouched artifacts from the Phase I assemblage. Although a greater percentage of marginally retouched artifacts are classified as complete, similar edge angle ranges are represented in both graphs, suggesting that marginally retouched artifacts were correctly classified and were completed more frequently than unifaces and bifaces. If the marginally retouched artifacts were being misclassified, one would expect a different range in edge angle variability, which does not appear to be the case.

Figures 16.5 and 16.6 provide the same comparisons for the Paleoindian assemblage. A considerable number of the incomplete, marginally retouched tools fall within the range of complete tools; otherwise the graphs appear similar to those that illustrate the Phase I assemblage. Figure 16.6 suggests that a number of marginally retouched tools in the Paleoindian assemblage may have been misclassified as incomplete. The range of edge angle variability on the 12 tools in question indicates that they were completed prior to discard. The extensive overlap between the complete and incomplete edge angle range distributions among marginally retouched tools suggests that the subjective criteria used to classify marginally retouched tools as complete or incomplete should be re-examined.

Table 16.2. Incomplete/complete tool ratios: Phase I and Paleoindian tools

	Tool Class	
Assemblage	Uni-/Bifaces	Marginal Retouch
Phase I	0.4	1.0
Paleoindian	0.6	0.7

In order to clarify tool completeness based on edge angle range, an edge angle cutoff point must identified. The histograms presented above suggest that such a cutoff point between 15 and 20 degrees could be used to distinguish between complete and incomplete tools. To aid in isolating an exact cutoff point, tables of z scores and associated probabilities were generated for the Phase I (Table 16.3) and Paleoindian (Table 16.4) assemblages. For both completeness categories the functional edge angle range means and standard deviations were used to compute z-scores for the values that fall between the complete and incomplete means. These z-scores were then used in conjunction with a table of one-tailed normal probabilities to derive the "p-values" or probabilities that these ranges represent one of the two completeness distributions.

The method is based on the fact that the probability that a given value (x_i) comes from the same population as a sample with mean ($\bar{X}$) and standard deviation (s), is given by the normal probability for a normal variable with a value of $(x_i - \bar{X})/s$, or the z-score of the value. Thus, the p-value associated with given edge angle range for a given category represents the probability that the value would be *misclassified* if it were placed in the other category. For example, in Table 16.3 an edge angle range of 13 degrees has only a 0.15 probability of belonging to the incomplete distribution and a probability of 0.48 of belonging to the complete one.

A probability cutoff of 0.15 (i.e., a 15 percent chance of being wrong) was used to define a zone of unclassifiable values in the overlap area between the complete and incomplete distributions. When the figures in Tables 16.3 and 16.4 are used, the overlap zones for the Phase I and Paleoindian assemblages were defined as 13.5–15.5 and 13.5–17.5 degrees, respectively. Unclassified Phase I and Paleoindian tools with edge angle ranges less than or equal to 13 degrees were classified as complete. Values greater than or equal to 16 degrees for the Phase I data and 18 degrees for the Paleoindian data were used to assign unclassified tools to the incomplete category. The larger range of unclassifiable values for the Paleoindian data reflects the greater variability present among the classified tools in that assemblage.

In a previous study, Schutt (1983:265) identified a 10–15 degree overlap zone on the basis of frequency distribution alone. This zone was much larger than the 3–5 degree overlap zone defined in the present study. Thus the use of z-scores and associated probabilities appears to provide a more accurate and efficient method for isolating edge angle range cutoff points for complete and incomplete tools.

It has been suggested that length/thickness ratios may also be used to distinguish stages in formal tool manufacture (Callahan 1979). To aid in determining whether these criteria are valid for classifying complete and incomplete tools, an analysis similar to that presented above was performed to examine artifact length and thickness. Frag-

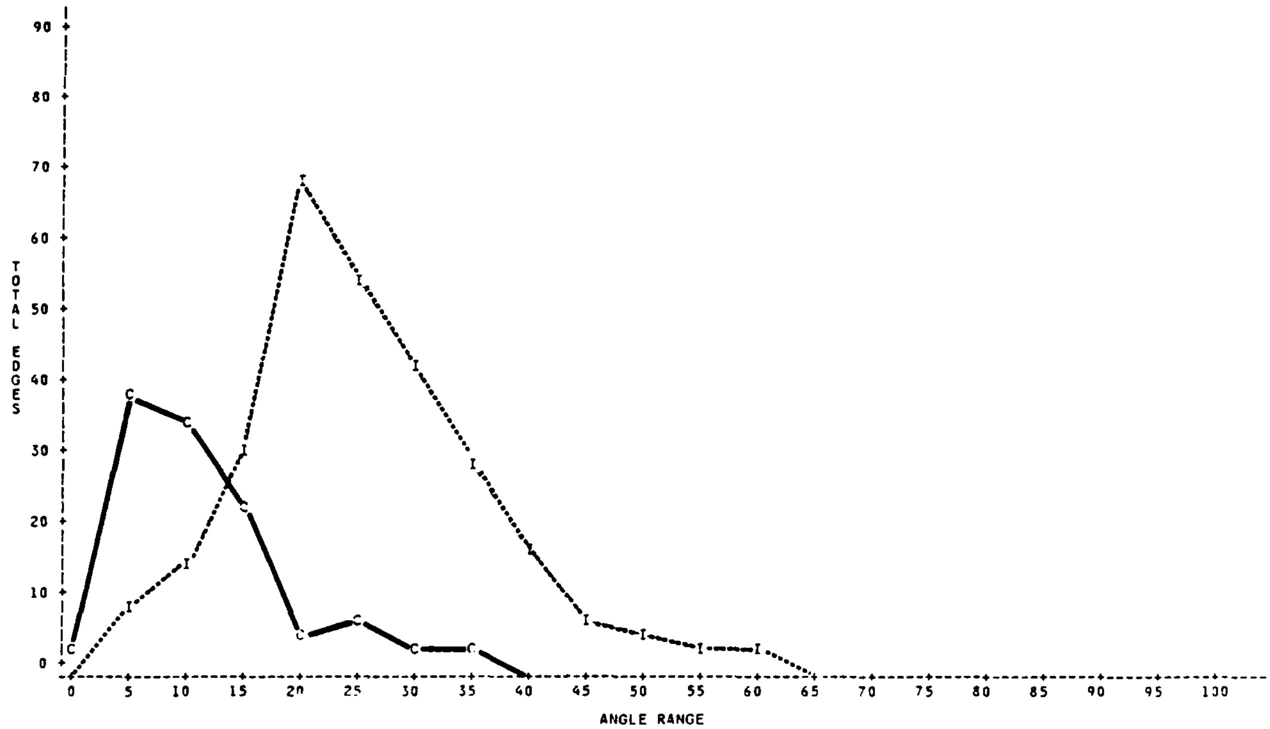


Figure 16.3. Edge angle range distribution for complete (C) vs incomplete (I) tools: Phase I—unifaces/bifaces

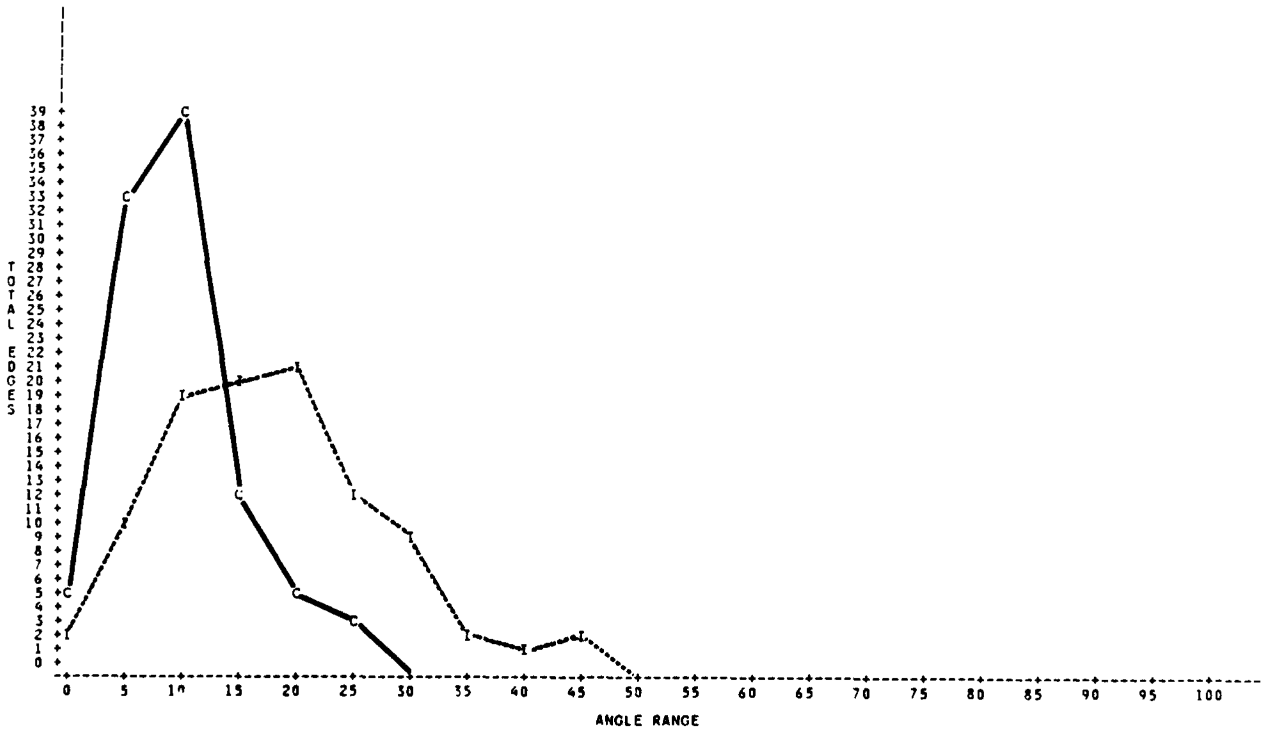


Figure 16.4. Edge angle range distribution for complete (C) vs incomplete (I) tools: Phase I—marginal retouch

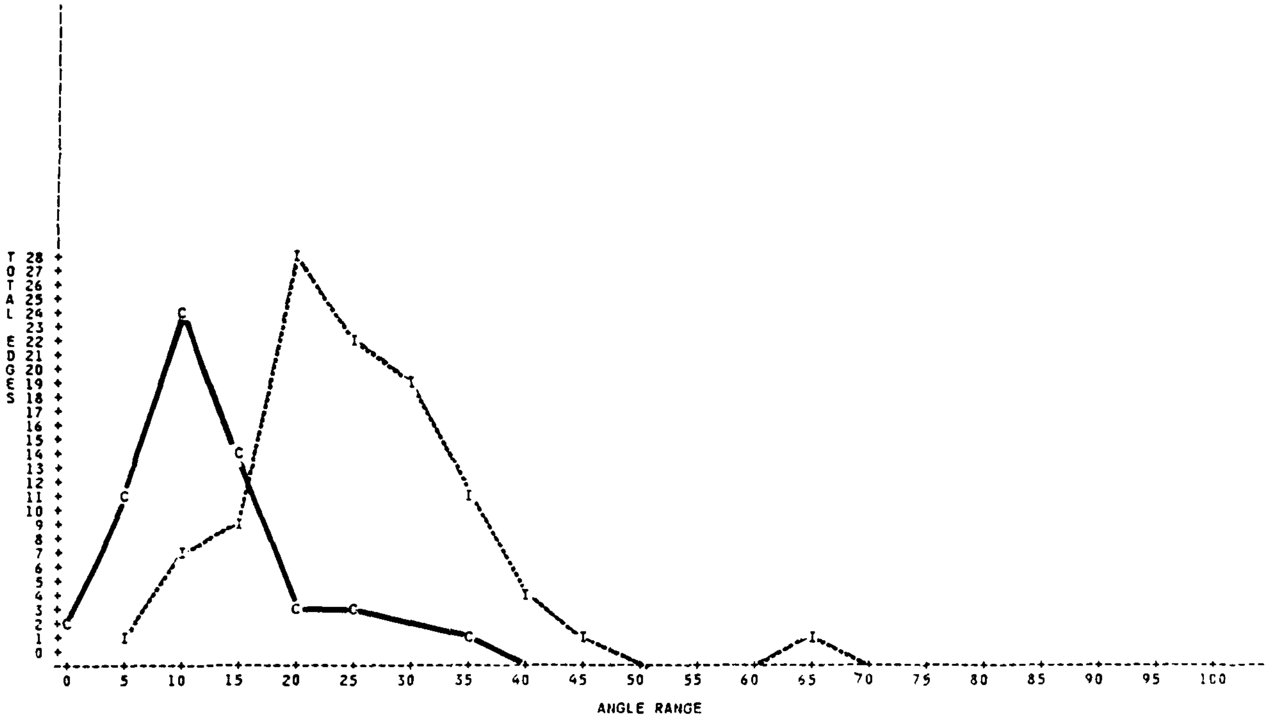


Figure 16.5. Edge angle range distribution for complete (C) vs incomplete (I) tools: Paleoindian—unifaces/bifaces

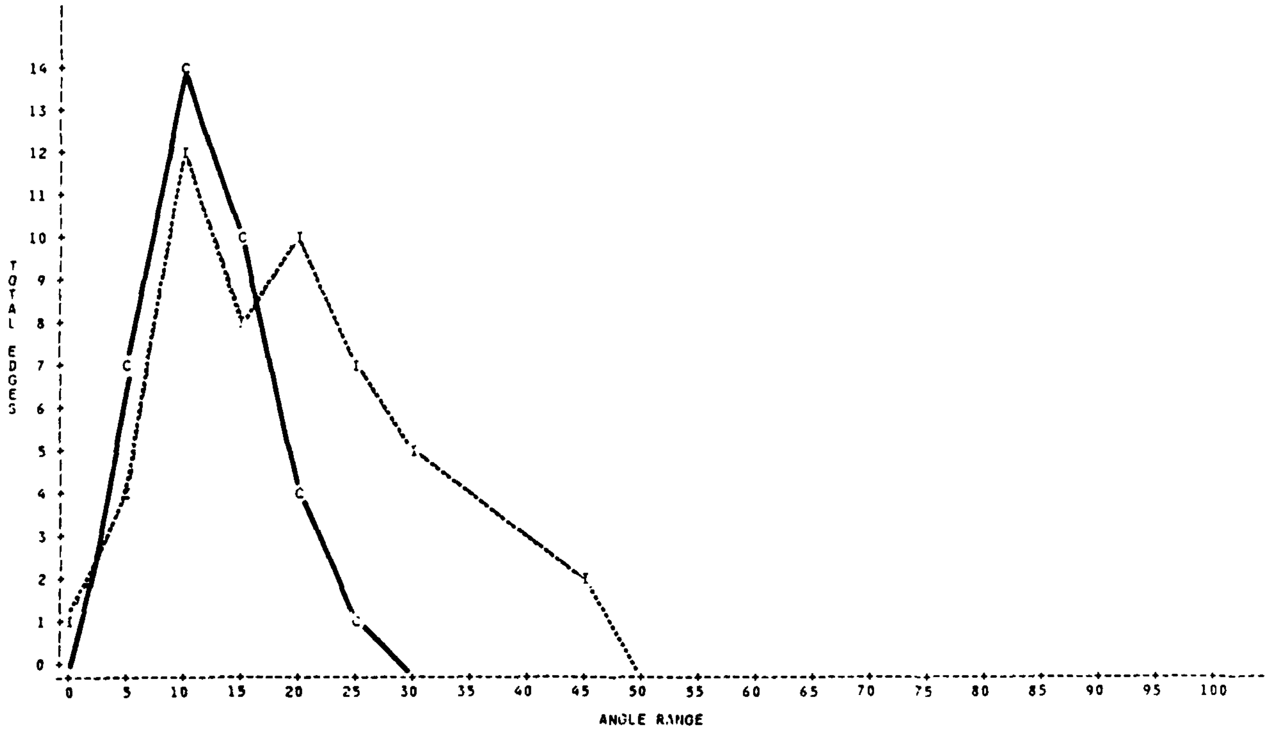


Figure 16.6. Edge angle range distribution for complete (C) vs incomplete (I) tools: Paleoindian—marginal retouch

Table 16.3. z-scores and probabilities for completeness data: Phase I

Edge Angle Range	Complete		Incomplete	
	z-score	p-value	z-score	p-value
11.0	0.13542	0.446141	−1.2734	0.101431
11.5	0.22222	0.412070	−1.2176	0.111682
12.0	0.30903	0.378650	−1.1618	0.122652
12.5	0.39583	0.346114	−1.1060	0.134357
13.0	0.48264	0.314676	−1.0502	0.146808
13.5	0.56944	0.284527	−0.9944	0.160009
14.0	0.65625	0.255832	−0.9386	0.173964
14.5	0.74306	0.228724	−0.8828	0.188669
15.0	0.82986	0.203309	−0.8270	0.204116
15.5	0.91667	0.179659	−0.7712	0.220293
16.0	1.00347	0.157817	−0.7154	0.237180
16.5	1.09028	0.137795	−0.6596	0.254756
17.0	1.17708	0.119581	−0.6038	0.272990
17.5	1.26389	0.103135	−0.5480	0.291849
18.0	1.35069	0.088397	−0.4922	0.311293
18.5	1.43750	0.075288	−0.4364	0.331279
19.0	1.52431	0.063716	−0.3806	0.351757

mentary tools were excluded so they would not misrepresent length/thickness ratios.

Figures 16.7 and 16.8 show the distribution of length/thickness ratios for complete and incomplete tools in the Phase I and Paleoindian assemblages. Both histograms suggest that the majority of complete and incomplete tools fall in the same length/thickness ratio range, with nearly complete overlap of the two distributions.

The results of *t*-tests comparing the length/thickness ratio means for complete versus incomplete tools in the Paleoindian and Phase I assemblages are presented in Table 16.5. As discussed above, box-plots were inspected to eliminate outlier values. The *t*-test results clearly indicate that there is no statistically significant relationship between tool completeness and the length/thickness ratios of whole tools.

This analysis supports the conclusion that the use of length/thickness ratios is not a valid criterion for distinguishing between complete and incomplete tools. On the other hand, edge angle variability as indicated by the range of edge angles present on functional edges appears to be a reliable predictor of completeness.

Determination of Tool Function Based on Wear Patterns

Tools with wear patterns identifiable under low-power microscopic inspection were initially assigned a function based on the direction of the wear. Tools with unidirectional wear were viewed as scrapers, while those with bidirectional wear were classified as cutting tools (Tringham et al. 1974). Previous study confirms the relationship between the direction of wear patterns on functional edges and basic tool function in terms of the scraping/cutting activities (Schutt 1982). Additional studies indicate that in many cases it is impossible to identify wear patterns using low-power magnification (Keeley 1974; Odell 1975; Schutt 1982). As a result, when high-power microscopy is unavailable as an identification aid, a large number of formal tools cannot be placed in a functional category.

Table 16.4. z-scores and probabilities for completeness data: Paleoindian

Edge Angle Range	Complete		Incomplete	
	z-score	p-value	z-score	p-value
11	−0.14834	0.441036	−1.2440	0.106752
12	0.02618	0.489558	−1.1294	0.129356
13	0.20070	0.420467	−1.0149	0.155079
14	0.37522	0.353749	−0.9003	0.183969
15	0.54974	0.291249	−0.7858	0.215993
16	0.72426	0.234454	−0.6712	0.251031
17	0.89878	0.184385	−0.5567	0.288866
18	1.07330	0.141569	−0.4422	0.329189
19	1.24782	0.106049	−0.3276	0.371605
20	1.42234	0.077464	−0.2131	0.415641
21	1.59686	0.055149	−0.0985	0.460763

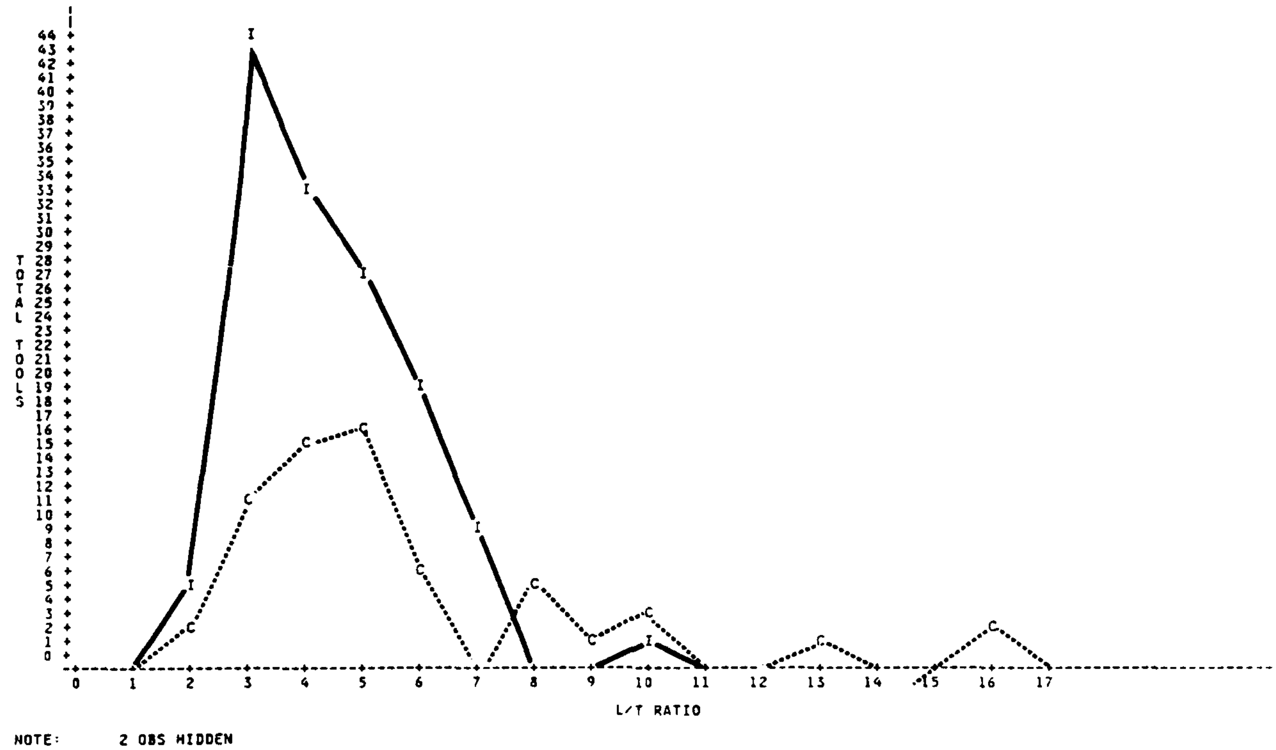


Figure 16.7. Length/Thickness (L/T) ratio distribution for complete (C) vs incomplete (I) tools: Phase I—whole tools only

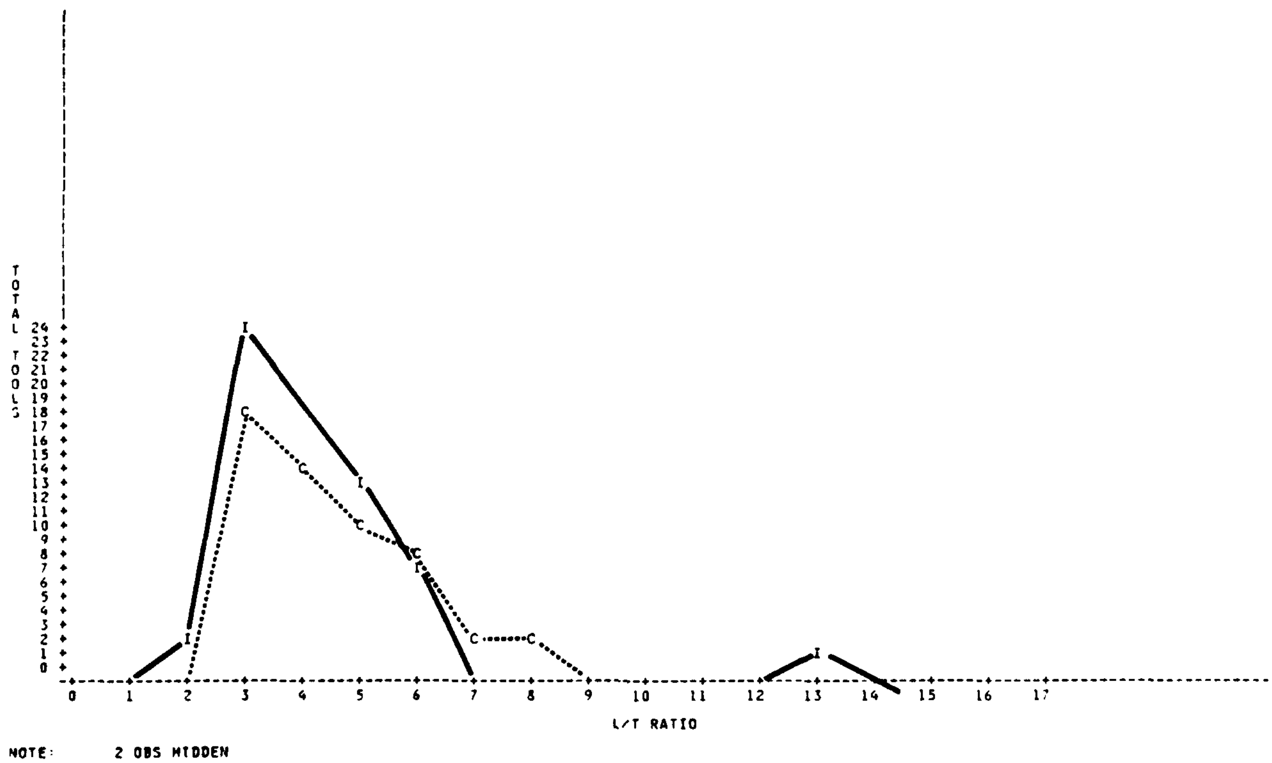


Figure 16.8. Length/Thickness (L/T) ratio distribution for complete (C) vs incomplete (I) tools: Paleoindian—whole tools only

Table 16.5. *t*-test for Phase I and Paleoindian tool length/width ratios vs completeness

	Complete		Incomplete				
Assemblage	Mean	95 Percent CI	Mean	95 Percent CI	*t*	p (> *t*)	N
Phase I	4.63	0.38	4.40	0.24	1.00	0.3196	197
Paleoindian	4.43	0.37	4.06	0.32	1.47	0.1432	116

To aid in assigning functional classifications to artifacts lacking wear patterns, edge angle ranges of all complete tools with wear patterns were plotted as frequency histograms. The distribution of edge angles for scraping tools (unidirectional wear) was compared with that of cutting tools (bidirectional wear) in an attempt to assign function to tools that are complete yet lack evidence of wear.

Table 16.6 shows the number of tools with unidirectional and bidirectional wear by tool category for each assemblage. Bidirectional wear is clearly underrepresented in both assemblages; tools with this wear pattern represent only 6 percent of the overall assemblage of 162 edges, thus limiting its interpretive value in the present study.

Frequency histograms were generated for the Phase I and Paleoindian assemblages. In each case utilized unifaces and bifaces were plotted separately from marginally retouched tools. Figure 16.9 (Phase I bifaces and unifaces) illustrates that the majority of bifaces and unifaces with unidirectional wear (91 percent) exhibit edge angles that range between 65 and 85 degrees. Thirty-two of the 35 unifaces and bifaces with unidirectional wear fall within this range. Only three tools exhibit mean edge angles that are less than 65 degrees. Complete unifaces and bifaces lacking evidence of use and exhibiting mean edge angles of 65 to 85 degrees can thus be classified as scraping tools with a 91 percent probability of being correct. The relative lack of tools with bidirectional wear in this particular assemblage does not allow the isolation of a mean edge angle range for cutting tools.

Phase I marginally retouched tools (Figure 16.10) exhibit a broad range of mean edge angles for unidirectionally worn edges. Ninety-seven percent of the edges represented (58 of 60) have mean edge angles of 55 to 85 degrees. In addition, the apparent bimodality of the distribution for unidirectional wear suggests functional diversity among scraping tools. There are two peaks, one at 60 degrees and one at 70 degrees, which have been tentatively identified as Type I and Type II scrapers among marginally retouched edges and are identified as such in the final tool type classifications (see below). Although it is not possible to determine the actual functions of these scraper types, functional diversity among scraping tools is clearly indicated by the different modes in edge angle measures.

Figure 16.11 shows the mean edge angle distributions for the Paleoindian unifaces and bifaces and indicates a mean edge angle range of 60–85 degrees for unidirectionally worn tools. Ninety-seven percent (28 of 29 artifacts) fall within this range. Figure 16.12 indicates a slightly larger range of mean edge angles (55–85 degrees) for marginally retouched scraping tools. All 29 of these utilized tools fall within this range.

The analysis of utilized tools from both Phase I and Paleoindian assemblages suggests that mean edge angles for utilized tools can be used to assign functional classifications to complete unifaces and bifaces as well as to marginally retouched tools that lack observable wear patterns. The limited number of tools with bidirectional wear in these assemblages prohibits the isolation of a specific edge angle range related to cutting activities.

Previous study suggests that cutting tools exhibit a different mean edge angle range than that exhibited by scraping tools (Schutt 1983:264–265). Although the sample was small (18 utilized unifacial and bifacial knives and scrapers), the data from the NMAP project (Figure 16.13) indicate that cutting and scraping tools generally exhibit different mean edge angles. In the NMAP case, cutting tools exhibited mean edge angles of 55 degrees and less, while scraping tools generally exhibited edge angles greater than 65 degrees.

The frequency histograms presented in this section suggest that the mean edge angle of unidirectionally worn tools can be used to assign function to complete tools lacking wear patterns, but these data offer little to suggest the

Table 16.6. Wear patterns: Phase I and Paleoindian tools

	Unifaces/Bifaces		Marginal Retouch		
Assemblage/Wear:	UNI	BIDI	UNI	BIDI	Total
Phase I	35	4	60	2	101
Paleoindian	29	2	29	1	61
Totals	64	6	89	3	162
Overall Percent	39.5	3.7	54.9	1.9	100.0

BIDI wear: 9 (5.6 percent)
UNI wear: 153 (94.4 percent)

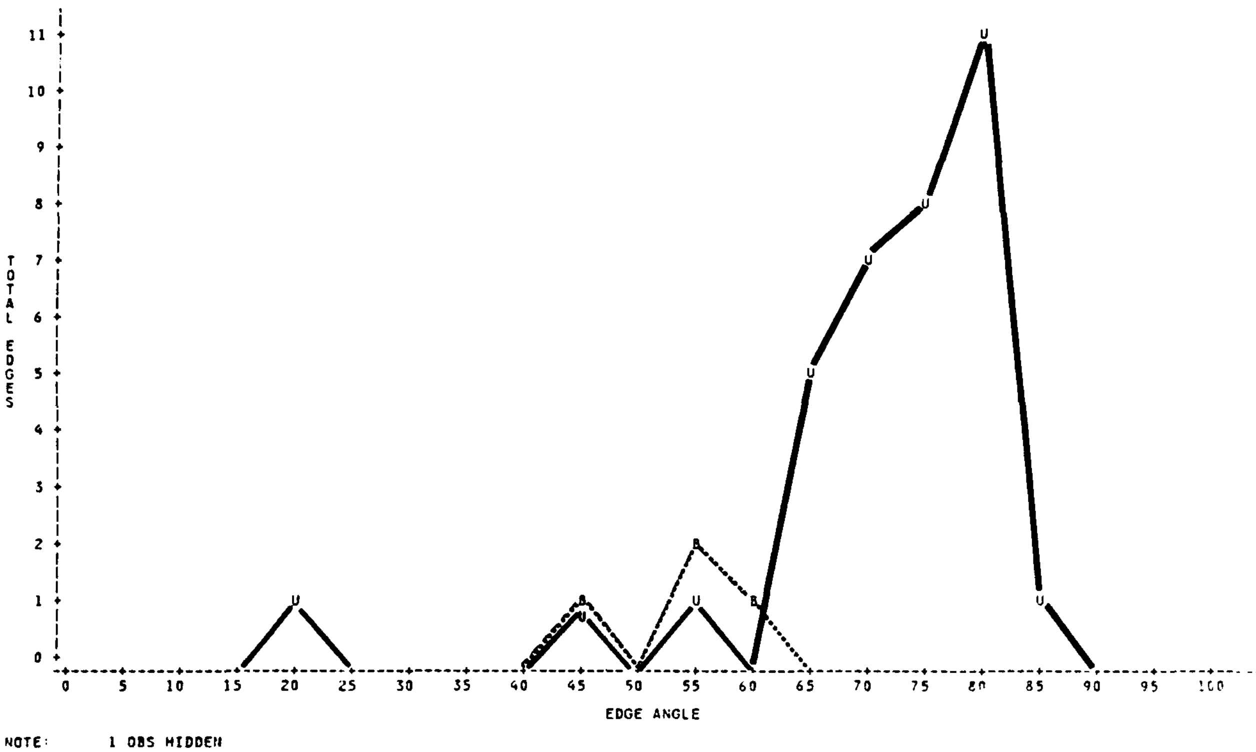


Figure 16.9. Mean edge angle distribution for unidirectional (U) vs bidirectional (B) wear: Phase I—complete unifaces/bifaces

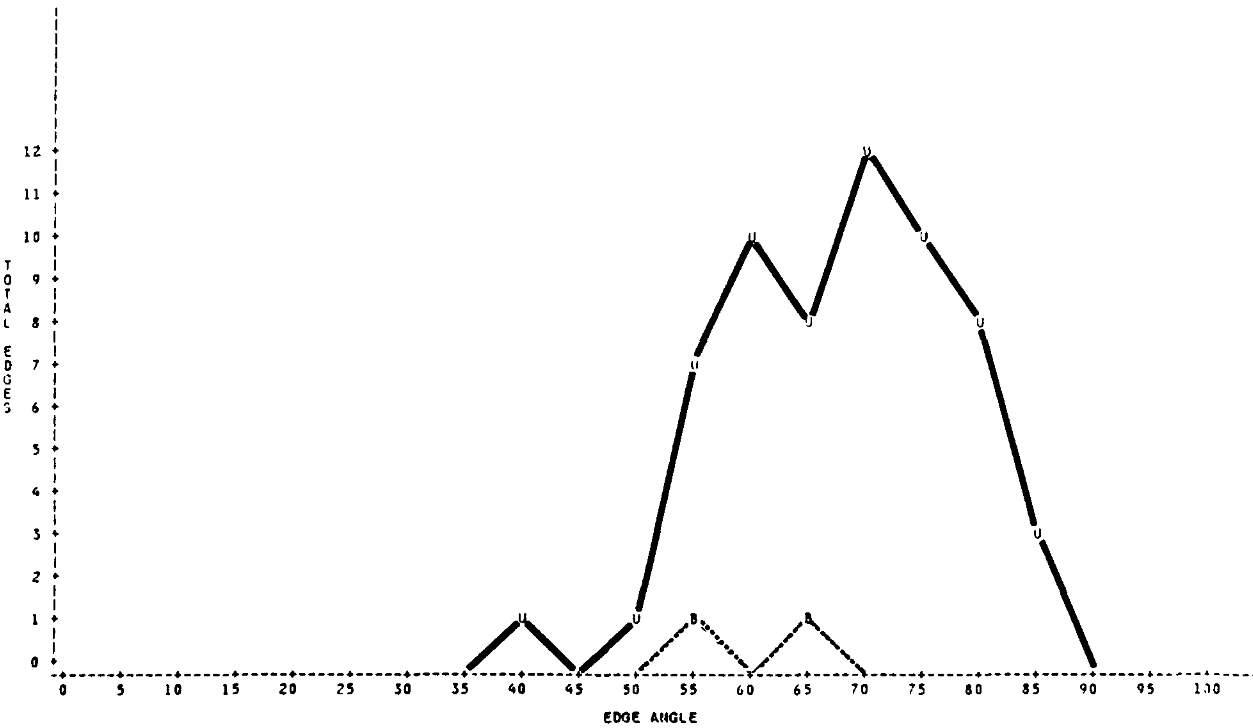


Figure 16.10. Mean edge angle distribution for unidirectional (U) vs bidirectional (B) wear: Phase I—complete marginal retouch

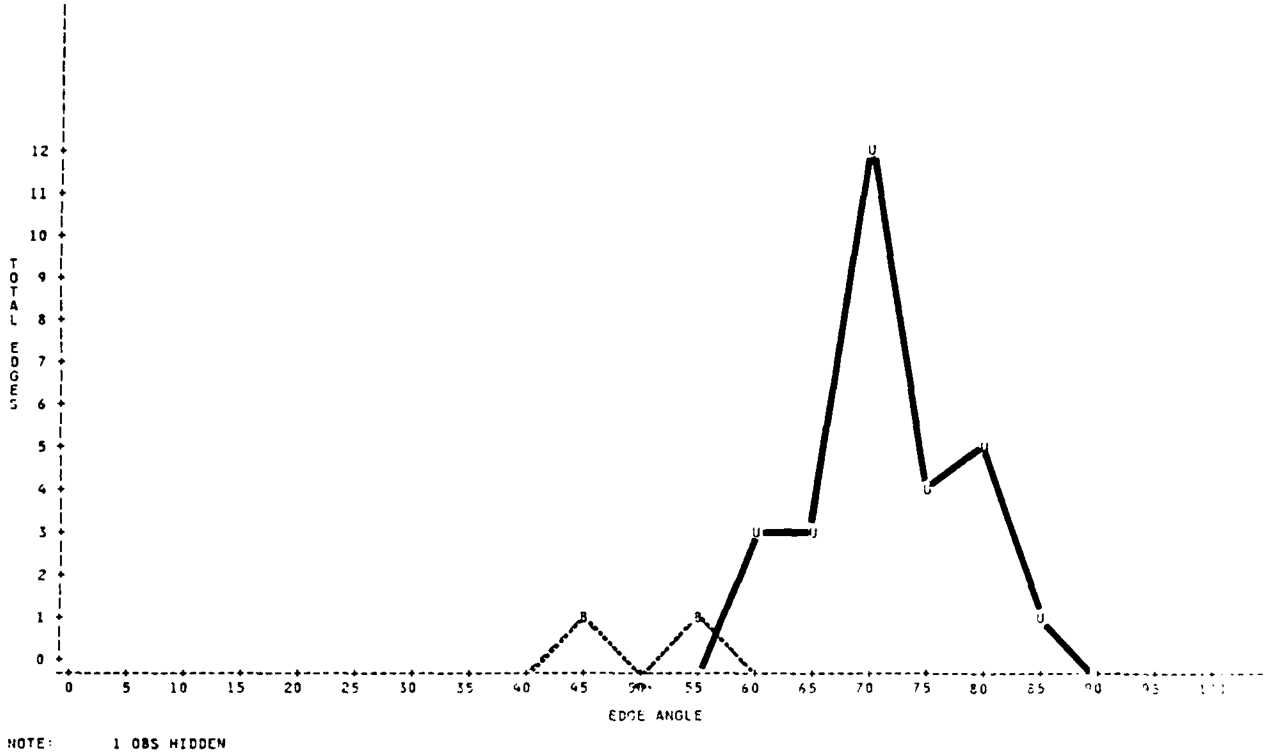


Figure 16.11. Mean edge angle distribution for unidirectional (U) vs bidirectional (B) wear: Paleoindian—complete unifaces/bifaces

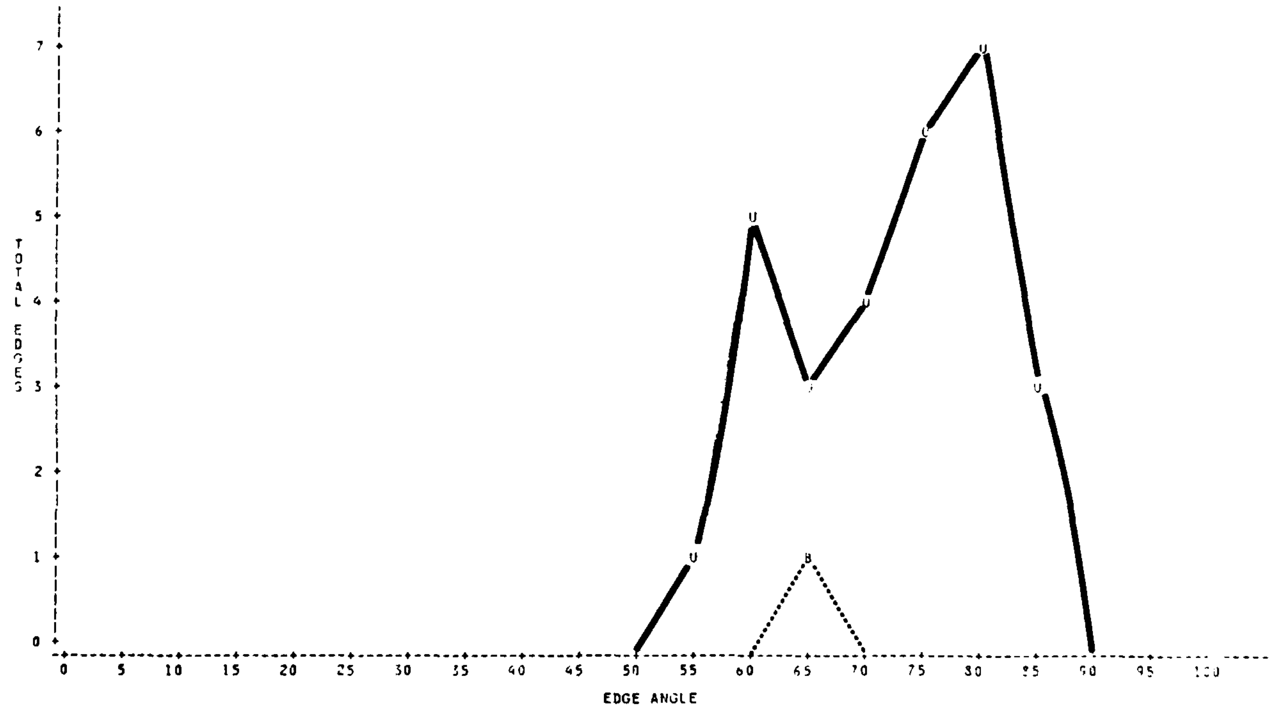


Figure 16.12. Mean edge angle distribution for unidirectional (U) vs bidirectional (B) wear: Paleoindian—complete marginal retouch

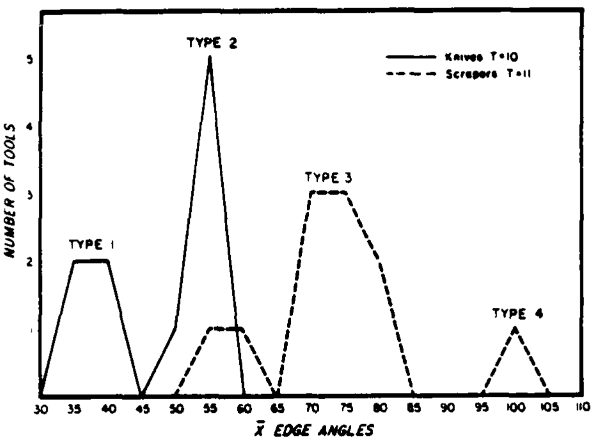


Figure 16.13. Edge angle variability exhibited by finished and utilized cutting tools recovered from NMAP Archaic sites (from Schutt 1983:265)

appropriate range of edge angles to be used in the identification of cutting activities.

A *t*-test was calculated for all unifacial, bifacial, and marginally retouched tools identified in both the Phase I and Paleoindian assemblages in order to determine whether a relationship exists between mean edge angle and observed wear. With outliers eliminated, the mean edge angle for unidirectionally worn edges is 69.8 degrees (n = 125, 95 percent confidence interval = 1.44), while that for bidirectional wear is 54.6 degrees (n = 8, 95 percent confidence interval = 5.13). The resulting *t* value was 5.11 with a significance level of 0.0001. Therefore, the means of the two samples are significantly different.

In order to determine cutoff points, as described in the previous section on completeness, a table of *z*-scores and associated probabilities was generated (Table 16.7). The data in this table indicate that unworn but complete tools with mean edge angles less than 62 degrees should be classified as cutting tools or knives, while those with mean edge angles greater than 62 degrees should be classified as scrapers.

Assignment of Final Tool Type

The relationships defined in the analyses described above were used to categorize previously unclassified tools in terms of completeness and function. Final tool types were then established based on these results and on attributes recorded during the initial examinations of the tools.

The methods discussed in the previous sections resulted in the tentative identification of tools that were used and discarded (complete) versus manufacturing failures (incomplete). The identification of these two classes of tools results in a more valid assessment of the activities that were carried out prehistorically. Furthermore, criteria were derived for a basic functional classification of formal tools that would otherwise be identified simply as indeterminate unifaces or bifaces. The following discussion compares the results of this reclassification with the initial functional classifications based purely on wear pattern analysis and overall artifact morphology.

Tool Function Classification Based upon Edge Angle

Table 16.8 describes the combined Phase I and Paleoindian artifacts in the Border Star 85 assemblage. A total of 110 artifacts were initially classified on the basis of wear pattern and morphology. Eighty-two percent (102 tools) exhibited wear indicating that they were used as scrapers. Most (97 tools) were probably used to scrape hard media (bone or wood); only five tools (4 percent) indicate use on a soft medium (e.g., hides). Cutting tools represent only 5 percent of the assemblage.

Other tool types (drill, perforator, and graver) made up only 4 percent of the assemblage. The 11 projectile points included in this study were too fragmentary to be used in the projectile point analysis presented in Chapter 15.

Table 16.7. z-scores and probabilities for all use-wear data

Edge Angle Range	Complete		Incomplete	
	z-score	p-value	z-score	p-value
56	0.19163	0.424015	−1.6813	0.046351
57	0.32659	0.371991	−1.5592	0.059472
58	0.46154	0.322206	−1.4371	0.075342
59	0.59649	0.275424	−1.3150	0.094252
60	0.73144	0.232254	−1.1929	0.116451
61	0.86640	0.193136	−1.0708	0.142126
62	1.00135	0.158329	−0.9487	0.171382
63	1.13630	0.127915	−0.8266	0.204227
64	1.27126	0.101819	−0.7045	0.240555
65	1.40621	0.079831	−0.5824	0.280143
66	1.54116	0.061639	−0.4603	0.322644
67	1.67611	0.046858	−0.3382	0.367600
68	1.81107	0.035065	−0.2161	0.414448
69	1.94602	0.025826	−0.0940	0.462548

Table 16.8. Final classification: Phase I and Paleoindian tools

	Original Use-Wear Classification					
		Unidirectional				
Final Classification*	None	Hard	Soft	Bidirectional	Circular	Total
Bifacial Scraper	1	0	0	0	0	1
Bifacial Knife	0	0	0	5	0	5
Unifacial Scraper	30	41	1	0	0	72
Unidirectional Marginally Retouched Scraper	4	51	3	0	0	58
Bidirectional Marginally Retouched Knife	0	0	0	1	0	1
Probable Bifacial Scraper	2	0	0	0	0	2
Probable Bifacial Knife	42	0	0	0	0	42
Probable Unifacial Scraper	25	0	0	0	0	25
Probable Unifacial Knife	5	0	0	0	0	5
Probable Unidirectional Marginally Retouched Scraper	14	0	0	0	0	14
Indeterminate Biface	187	0	0	0	0	187
Indeterminate Uniface	113	3	1	0	0	117
Indeterminate Bifacial Marginally Retouched Tool	3	0	0	0	0	3
Indeterminate Unifacial Marginally Retouched Tool	118	2	0	1	0	121
Biface/Point	11	0	0	0	0	11
Biface/Drill	1	0	0	0	1	2
Graver	1	0	0	0	0	1
Perforator	1	0	0	0	0	1
Total	558	97	5	7	1	668

*Originally classified (N = 110; 16%)
Finally classified (N = 240; 36%)
Originally unclassified (N = 558; 84%)
Finally unclassified (N = 428; 64%)

The presence of incomplete tools, manufacturing failures, and tools that were utilized and then exhausted and discarded has skewed previous interpretations of site function. This paper indicates that the range of edge angle variability on functional edges can be used to distinguish formal tools that were completed, utilized, and discarded from artifacts that were discarded prior to completion, due to manufacturing errors or problems with raw material. Once the incomplete tools are withdrawn from consideration, other methods outlined in this paper can be used to assign probable functional classifications to tools that otherwise lack evidence of how they were used.

Table 16.8 indicates tool function classifications obtained when wear pattern and morphology alone were used to classify artifacts; it also shows tool function classifications obtained when mean edge angle variability on complete tools was considered in addition to wear patterns and morphology. When wear patterns and morphology were the only criteria used to determine tool function, 84 percent of the assemblage (558 artifacts) remains unclassified; only 16 percent of the formal tools could be assigned to functional categories. Once the methods described in this analysis were applied, however, an additional 19 percent (130 tools) could be classified, resulting in the functional classification of more than twice as many artifacts (240 artifacts; 36 percent of the entire assemblage).

Material Selection

Material type was determined for the 670 formal and marginally retouched tools in the Paleoindian and Phase I assemblages in order to collect data concerning source areas and overall material selection in the study area. Although 39 material types were recorded, 88 percent of the assemblage (591 artifacts) were manufactured from 10 material types (Table 16.9). Appendix 4 presents a discussion of all material types encountered; only the most common materials will be discussed here.

The most commonly used raw material was a mottled gray, black, tan, and brown chert, described as material type number 1032 by Warren (1979), which occurs locally in the Jarilla Mountains and probably in the Sacramento Mountains as well. Fifty percent (332) of the artifacts were manufactured from this material type. Some pieces of this material are very easy to knap while others are not well suited for tool manufacture. The popularity of this material is probably due to its relative abundance and close

Table 16.9. Common material types

Material Type	No. of Artifacts	Description
1032	332	Mottled gray to black, tan to brown chert. Jarilla Mountains, Bear Peak, and possibly the Sacramento Mountains.
1043	35	Gray to Retouchddish purple, dull to glossy chert. Southeastern New Mexico, Jarilla Mountains, Bear Peak, San Andreas Mountains, and Sacramento Mountains.
1072	11	Yellow brown chert with black mossy inclusions (may grade to Retouchd). Upper Permian beds.
1233	31	Chalcedony with abundant yellow and Retouchd inclusions. Permian marine limestone, northeastern Jarilla Mountains.
1505	10	Porcellanites. Organ Mountains.
1630	51	Cream cherts. Undetermined.
1650	13	Olive green to gray chert. Undetermined.
1660	47	Light tan to buff chert. Undetermined.
2208	16	Fine-grained, light brown to orange brown quartzitic sandstone. Undetermined.
4354	55	Red, yellow, and gray hornfels. Jarilla Mountains.

proximity to the study area. Eight percent (55) of the artifacts were manufactured from hornfels (type 4354), which also occurs in the Jarilla Mountains. Local cream-colored cherts (type 1630; 51 artifacts, 8 percent), tan cherts (type 1660; 47 artifacts, 7 percent), and olive green to gray cherts (type 1650; 13 artifacts, 2 percent) made up 17 percent of the artifact assemblage. Other cherts included a gray purple chert (type 1043; 35 artifacts, 5 percent) and a yellow brown chert (type 1072; 11 artifacts, 2 percent). A local chalcedony (type 1233) with red and yellow inclusions was also selected (31 artifacts, 5 percent). Ten artifacts were manufactured from a porcellanite found in the Organ Mountains. Sixteen artifacts (2 percent) were manufactured from a quartzitic sandstone (type 2208) of undetermined origin.

The remaining 79 artifacts were manufactured from 28 material types that were used infrequently. With the exception of basalt (type 3050), all identified source areas can be considered local. A single basalt artifact was manufactured from volcanics that may originate in the flows near Carrizozo, New Mexico. Although the obsidian (type 3523) originates in the Jemez Mountains, it is known to occur in the Santa Fe gravels as far south as Las Cruces (Appendix 4).

Table 16.10–16.12 shows the breakdown of the final tool types for the most common material types (the rest are lumped as "other") for the Phase I and Paleoindian assemblages combined. Functionally complete and incomplete tools and other tools are listed separately. Without site-specific data and information on debitage, only general statements can be made concerning success rates, material quality, and material selection as they relate to complete and incomplete tools.

Table 16.13 indicates that among common material type classes there are generally more incomplete (299) than complete (251) tools, which is true in 7 of 10 material classes (4354, 2208, 1660, 1650, 1630, 1505, and 1032). Functionally complete tools outnumber functionally incomplete tools in two material classes (1043 and 1233), while the two kinds of tools are equally represented in class 1072. The high ratio of complete tools within these three categories may indicate that they represent better overall material quality. It would be necessary to examine debitage material classes associated with these tools in order to determine whether this is the case. Other subsistence and technological factors may contribute to these differences in the ratio of complete to incomplete tools.

When Phase I and Paleoindian assemblages are examined (Tables 16.14 through 16.18), it is clear that material selection, tool types, and the ratio of complete to incomplete tools vary considerably between the two assemblages. Phase I tools (Tables 16.14–16.16) were primarily manufactured from nine material classes. A total of 446 artifacts fell within these classes, and the remaining 113 artifacts were manufactured from 28 other materials. Tables 16.17–16.18 indicate the most common materials represented in the Paleoindian assemblage. Of the 122 Paleoindian tools included in this study, 105 were assigned to six material classes. Seventeen tools were manufactured from four other materials. In addition, the Paleoindian assemblage did not exhibit tools in four material classes that were represented in the Phase I assemblage. These were porcellanite (type 1505), cream chert (type 1650), quartzitic sandstone (type 2208), and hornfels (type 4353).

These data indicate that material selection was more restricted in the Paleoindian assemblage than in the Phase

Table 16.10. Final tool types by material: Phase I/Paleoindian—complete

Frequency Column %	Material Class										
	1032	1043	1072	1233	1505	1630	1650	1660	2208	Other	Total
Biface Scraper	0	0	0	0	0	1	0	0	0	0	1
	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00	
Biface Knife	3	0	0	0	0	0	1	0	0	1	5
	2.33	0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	2.86	
Uniface Scraper	40	3	4	10	0	1	0	5	0	9	72
	31.01	13.64	80.00	58.82	0.00	6.67	0.00	29.41	0.00	25.71	
Unimarginal Scraper	30	5	1	1	0	3	2	5	0	11	58
	23.26	22.73	20.00	5.88	0.00	20.00	50.00	29.41	0.00	31.43	
Bimarginal Knife	1	0	0	0	0	0	0	0	0	0	1
	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
? Bifacial Scraper	1	0	0	0	0	0	0	0	0	1	2
	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.86	
? Bifacial Knife	18	9	0	1	0	6	0	0	3	5	42
	13.95	40.91	0.00	5.88	0.00	40.00	0.00	0.00	50.00	14.29	
? Unifacial Scraper	19	1	0	3	0	0	0	1	1	0	25
	14.73	4.55	0.00	17.65	0.00	0.00	0.00	5.88	16.67	0.00	
? Unifacial Knife	1	0	0	0	0	0	0	0	1	3	5
	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	8.57	
? Unimarginal Scraper	4	2	0	1	0	3	0	1	0	3	14
	3.10	9.09	0.00	5.88	0.00	20.00	0.00	5.88	0.00	8.57	
Indeterminate Biface	2	1	0	0	0	0	0	1	0	1	5
	1.55	4.55	0.00	0.00	0.00	0.00	0.00	5.88	0.00	2.86	
Indeterminate Uniface	1	0	0	0	0	0	0	0	0	0	1
	0.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Indeterminate Unimarginal	9	1	0	1	1	1	1	4	1	1	20
Retouch	6.98	4.55	0.00	5.88	100.00	6.67	25.00	23.53	16.67	2.86	
Total	129	22	5	17	1	15	4	17	6	35	251

I assemblage. The former represents a smaller range of local material types than that found in the Phase I sample and exhibits little evidence for the use of exotic materials.

The Paleoindian assemblage (Tables 16.14–16.17) exhibits fewer tool types than the Phase I assemblage (Table 16.14–16.16). While the Paleoindian assemblage contains only scraping tools, the Phase I assemblage includes a number of cutting tools, two drills, and a graver. The limited number of tool types may indicate that a smaller range of activities was performed at Paleoindian sites. However, without site-specific chronological information for the Phase I assemblage, the variability identified between phases remains speculative.

The Phase I assemblage generally exhibits more incomplete tools than complete tools (Table 16.19). Only in material types 1043 and 1233 were there a greater number of functionally complete than functionally incomplete tools found. In the Paleoindian assemblage, high ratios of complete to incomplete tools are also seen in material types 1032 and 1660. Fifty-five percent of the type 1032 tools and 67 percent of the type 1660 tools were classified as complete. This is a marked difference from the Phase I

Table 16.11. Final tool types by material: Phase I/Paleoindian-incomplete

Frequency Column %	Material Class										
	1032	1043	1072	1233	1505	1630	1650	1660	2208	Other	Total
Indeterminate Biface	99	5	0	0	1	19	5	12	9	30	180
	50.77	50.00	0.00	0.00	25.00	57.58	55.56	44.44	90.00	32.61	
Indeterminate Uniface	65	1	4	9	1	7	3	7	1	18	116
	33.33	10.00	80.00	64.29	25.00	21.21	33.33	25.93	10.00	19.57	
Indeterminate Bimarginal	2	0	0	0	0	0	0	0	0	1	3
Retouch	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.09	
Indeterminate Unimarginal	29	4	1	5	2	7	1	8	0	43	100
Retouch	14.87	40.00	20.00	35.71	50.00	21.21	11.11	29.63	0.00	46.74	
Total	195	10	5	14	4	33	9	27	10	92	399

Table 16.12. Final tool types by material: Phase I/Paleoindian—other

Frequency Column %	Material Class						
	1032	1043	1072	1630	1660	Other	Total
Biface/Point	5	1	0	3	1	1	11
	100.00	33.33	0.00	100.00	100.00	50.00	
Biface/Drill	0	1	1	0	0	0	2
	0.00	33.33	100.00	0.00	0.00	0.00	
Graver	0	1	0	0	0	0	1
	0.00	33.33	0.00	0.00	0.00	0.00	
Perforator	0	0	0	0	0	1	1
	0.00	0.00	0.00	0.00	0.00	50.00	
Total	5	3	1	3	1	2	15

Table 16.13. Ratios of complete to incomplete tools for common material types

	Material Type Codes										
	1032	1043	1072	1233	1505	1630	1650	1660	2208	4354	Total
Phase I and Paleoindian	0.56	1.67	1.00	1.06	0.01	0.41	0.33	0.35	0.46	0.15	0.51
N =	327	32	10	31	10	48	12	46	16	55	587

Table 16.14. Final tool types by material: Phase I—complete

Frequency Column %	Material Class										
	1032	1043	1072	1233	1505	1630	1650	1660	2208	Other	Total
Biface Scraper	0	0	0	0	0	1	0	0	0	0	1
	0.00	0.00	0.00	0.00	0.00	7.14	0.00	0.00	0.00	0.00	
Biface Knife	3	0	0	0	0	0	1	0	0	0	4
	2.97	0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	
Uniface Scraper	23	2	1	5	0	0	0	1	0	2	34
	22.77	9.52	100.00	55.56	0.00	0.00	0.00	9.09	0.00	8.33	
Unimarginal Scraper	22	5	0	0	0	3	2	4	0	10	46
	21.78	23.81	0.00	0.00	0.00	21.43	50.00	36.36	0.00	41.67	
Bimarginal Knife	1	0	0	0	0	0	0	0	0	0	1
	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
? Bifacial Scraper	1	0	0	0	0	0	0	0	0	1	2
	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.17	
? Bifacial Knife	18	9	0	1	0	6	0	0	3	5	42
	17.82	42.86	0.00	11.11	0.00	42.86	0.00	0.00	50.00	20.83	
? Unifacial Scraper	17	1	0	1	0	0	0	0	1	0	20
	16.83	4.76	0.00	11.11	0.00	0.00	0.00	0.00	16.67	0.00	
? Unifacial Knife	1	0	0	0	0	0	0	0	1	2	4
	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	8.33	
? Unimarginal Scraper	4	2	0	1	0	3	0	1	0	3	14
	3.96	9.52	0.00	11.11	0.00	21.43	0.00	9.09	0.00	12.50	
Indeterminate Biface	2	1	0	0	0	0	0	1	0	0	4
	1.98	4.76	0.00	0.00	0.00	0.00	0.00	9.09	0.00	0.00	
Indeterminate Unimarginal Retouch	9	1	0	1	1	1	1	4	1	1	20
	8.91	4.76	0.00	11.11	100.00	7.14	25.00	36.36	16.67	4.17	
Total	101	21	1	9	1	14	4	11	6	24	192

Table 16.15. Final tool types by material: Phase I—incomplete

Frequency Column %	Material Class									
	1032	1043	1233	1505	1630	1650	1660	2208	Other	Total
Indeterminate Biface	98 56.32	5 50.00	0 0.00	1 25.00	19 61.29	5 55.56	12 48.00	9 90.00	30 34.48	179
Indeterminate Uniface	49 28.16	1 10.00	1 50.00	1 25.00	6 19.35	3 33.33	6 24.00	1 10.00	15 17.24	83
Indeterminate Bimarginal Retouch	2 1.15	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1 1.15	3
Indeterminate Unimarginal Retouch	25 14.37	4 40.00	1 50.00	2 50.00	6 19.35	1 11.11	7 28.00	0 0.00	41 47.13	87
Total	174	10	2	4	31	9	25	10	87	352

Table 16.16. Final tool types by material: Phase I—other

Frequency Column %	Material Class						
	1032	1043	1072	1630	1660	Other	Total
Biface/Point	5 100.00	1 33.33	0 0.00	3 100.00	1 100.00	1 50.00	11
Biface/Drill	0 0.00	1 33.33	1 100.00	0 0.00	0 0.00	0 0.00	2
Graver	0 0.00	1 33.33	0 0.00	0 0.00	0 0.00	0 0.00	1
Perforator	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1 50.00	1
Total	5	3	1	3	1	2	15

Table 16.17. Final tool types by material: Paleoindian—complete

Frequency Column %	Material Class							
	1032	1043	1072	1233	1630	1660	Other	Total
Biface Knife	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1 9.09	1
Uniface Scraper	19 59.38	1 50.00	4 80.00	8 66.67	1 100.00	4 66.67	7 63.64	44
Unimarginal Scraper	10 31.25	0 0.00	1 20.00	1 8.33	0 0.00	1 16.67	1 9.09	14
? Unifacial Scraper	2 6.25	1 50.00	0 0.00	2 16.67	0 0.00	1 16.67	0 0.00	6
? Unifacial Knife	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1 9.09	1
Indeterminate Biface	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1 9.09	1
Indeterminate Uniface	1 3.13	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1
Indeterminate Unimarginal Retouch	0 0.00	0 0.00	0 0.00	1 8.33	0 0.00	0 0.00	0 0.00	1
Total	32	2	5	12	1	6	11	69

Table 16.18. Final tool types by material: Paleoindian—incomplete

Frequency Column %	Material Class						Total
	1032	1072	1233	1630	1660	Other	
Indeterminate Biface	2 8.33	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	2
Indeterminate Uniface	18 75.00	4 80.00	9 69.23	1 50.00	2 66.67	4 66.67	38
Indeterminate Unimarginal Retouch	4 16.67	1 20.00	4 30.77	1 50.00	1 33.33	2 33.33	13
Total	24	5	13	2	3	6	53

Table 16.19. Ratios of complete to incomplete tools: Paleoindian vs Phase I assemblages

	Material Type Codes										Total
	1032	1043	1072	1233	1505	1630	1650	1660	2208	4354	
Paleoindian Assemblage	1.24	All	0.50	0.78	—	0.50	—	2.00	—	—	1.14
N =	56	2	10	2.5	—	3	—	9	—	—	105
Phase I Assemblage	0.47	1.50	—	5.00	None	0.41	0.30	0.19	0.46	0.15	0.42
N =	271	30	—	6	10	45	13	37	16	55	483

assemblage, where only 31 percent of the type 1032 tools and 16 percent of the type 1660 tools were complete. In only one material category did the Phase I assemblage exhibit a greater number of complete tools than the Paleoindian assemblage, i.e., within the type 1233 material class. Overall the Phase I assemblage exhibited a ratio of 0.42 complete to incomplete tools, while the Paleoindian ratio was 1.14.

Conclusions

It is evident from the analysis of tools collected from the Phase I survey and from LA 63880 that the methods presented in this paper can be used successfully to gain a better understanding of overall site content as well as increased information concerning tool function, manufacturing success rates, and material selection. Specific implications of the analysis are summarized here.

The range of edge angle variability that occurs on the functional edges of formal tools can be used with a high degree of accuracy to distinguish between complete and incomplete tools.

Length/thickness ratios are not a valid criterion for isolating complete and incomplete tools. The analysis of individual tool forms might reveal a stronger relationship.

A table of z-scores and normal probabilities can be used to select the exact edge angle range cutoff point for distinguishing between complete and incomplete tools, resulting in fewer artifacts being classified as biface or uniface unknown. Although the frequency histograms provide a good indication of this cutoff point, z-scores are more accurate.

The edge angle range cutoff points used to distinguish between functionally complete and incomplete unifaces and bifaces versus marginally retouched artifacts are not identical. It may be possible to isolate an edge angle range cutoff point that applies to all bifaces and unifaces as well as a point range for marginally retouched artifacts, regardless of the archeological location or time period. Similar cutoff points were determined in the Paleoindian and Phase I assemblages. In addition, the cutoff point identified for the Border Star 85 survey is similar to that for the Navajo Mine Archeological Program in northern New Mexico.It would be necessary to examine large assemblages of formal tools with relatively equal numbers of unifacial and bifacial tools to test these findings further.

The mean edge angle of functional edges can be used to classify artifacts as scraping or cutting tools with a high degree of success. This classification results in a marked increase in the number of tools that can be assigned to functional categories.

A large number of formal tools recovered archeologically represent manufacturing failures rather than tool use activities that were carried out at site locations prehistorically. Tools must be identified as complete or incomplete before they are assigned functional meanings within archeological assemblages. The continued misclassification of those formal tools which in reality are manufacturing failures into categories representing functional variability will perpetuate the invalid assignment of site type and ultimately undermine regional studies that rely heavily on determinations of site function for interpretation of the archeological record.

Chapter 17

ANALYSIS OF PALEOINDIAN TOOLS FROM LA 63880

Janette M. Elyea

Introduction

One hundred and thirty-two formal lithic tools or tool fragments were collected from LA 63880 during the Border Star Phase I survey. The area was originally located when a Transect Recording Unit (TRU) crossed a concentration of lithic artifacts which included flakes with abraded striking platforms and well-made transverse endscrapers. The field personnel assigned the materials to the Paleoindian period and concluded that they represented a rare archeological manifestation. At the request of the Corps of Engineers, areas outside the TRUs were examined for further evidence of Paleoindian occupation. The examination located similar artifacts in a large area to the east and northeast of the initial discovery.

Owing to the rare nature of the archeological manifestation, all retouched artifacts within and outside of the TRUs were recorded and collected. We were concerned that shifting sands might cover the artifacts within a very short time. Nails with aluminum tags displaying the collection and TRU numbers were placed at locations where artifacts had been collected. The area was covered in a zig-zag manner with personnel located at approximate 17 m intervals, or half the normal transect spacing. Artifacts were assigned to the nearest TRU.

Paleoindian artifact types were discovered in 41 of the recording units or TRUs; these units are distributed within a total site area of 72,000 sq m (Figure 17.1). Although the artifacts appear to be scattered over an extremely large area, much of the area is covered with high coppice dunes. Most of the artifacts were found in small, highly deflated areas with exposed caliche nodules.

The area, located approximately 2 km northwest of a large playa, contains two other archeological manifestations recorded using standard TRU survey methods (LA 63787 and LA 63790). Neither site area contained artifacts suggestive of a Paleoindian occupation; lithic materials from these sites are therefore not included in this descriptive report. All artifacts suggestive of a Paleoindian occupation within the area were catalogued in the laboratory with the unique WSMR site number 3000. The Laboratory of Anthropology (LA) number 63880 was subsequently assigned to this site.

Assemblage Description

Appendix 11 contains a list of the artifacts collected from the site area. A sample of these are illustrated in Figure 17.2. The majority were transverse endscrapers (Table 17.1), but other less common artifact types were also recorded. Transverse endscrapers are unifacial flakes, roughly triangular in outline, whose distal ends have been modified into an arc-shaped working edge that is perpendicular to the long axis of the scraper (Judge 1973). These Paleoindian scrapers commonly exhibit unilateral or bilateral retouch modification, and one or both distal corners may be modified into a sharp point called a spur. All but 14 of the 101 transverse endscrapers exhibited modification on the right or left edge; lack of modification on these 14 artifacts is probably the result of edge damage or the fragmentary condition of the artifacts.

Sidescrapers are flakes that exhibit modification to the lateral rather than distal edges (Figure 17.2n). Of the 18 sidescrapers recorded, only 3 did not exhibit damage to the distal flake portion. The sidescrapers whose distal portions are absent may have originally been used as transverse endscrapers.Beaked or chisel scrapers were represented by three items exhibiting elongated, wide scraping tips (Figure 17.2o). Judge (1973) has suggested that these rare artifacts were used to hollow out deep narrow places such as the distal ends of long bone shafts.

The majority of all scrapers exhibited more than one working edge; a combination of straight, convex, and concave scraping edges was usually present. Of the total scraper assemblage, 10 exhibited one or more burinated edges, 50 had one or more spurs (Figure 17.2a-j), and two had double scraping edges where one edge evidenced scraping from two opposing directions.

Other artifact types included one large biface, which may relate to the Paleoindian occupation or to later occupations (Figure 17.2r), and two projectile point midsections. One of the projectile points is a midsection manufactured from chalcedony (material type 1052) with parallel flaking and a diamond cross section; it is reminiscent of points from the Cody complex (Figure 17.2p). The other point is manufactured from basalt, has a diamond cross section (Figure 17.2q), and may also be from the Cody complex. Also present was one spokeshave or concave working edge manufactured on a thick flake, one burin spall struck from a convex scraping edge, and an abrader (Figure 17.2s) which exhibited several deep narrow striations and may have been used to prepare striking platforms or to grind projectile point bases for hafting.

Comparison with the Border Star 85 Phase I Assemblage

The assessment that the LA 63880 assemblage belonged to the Paleoindian period was based in part upon the pres-

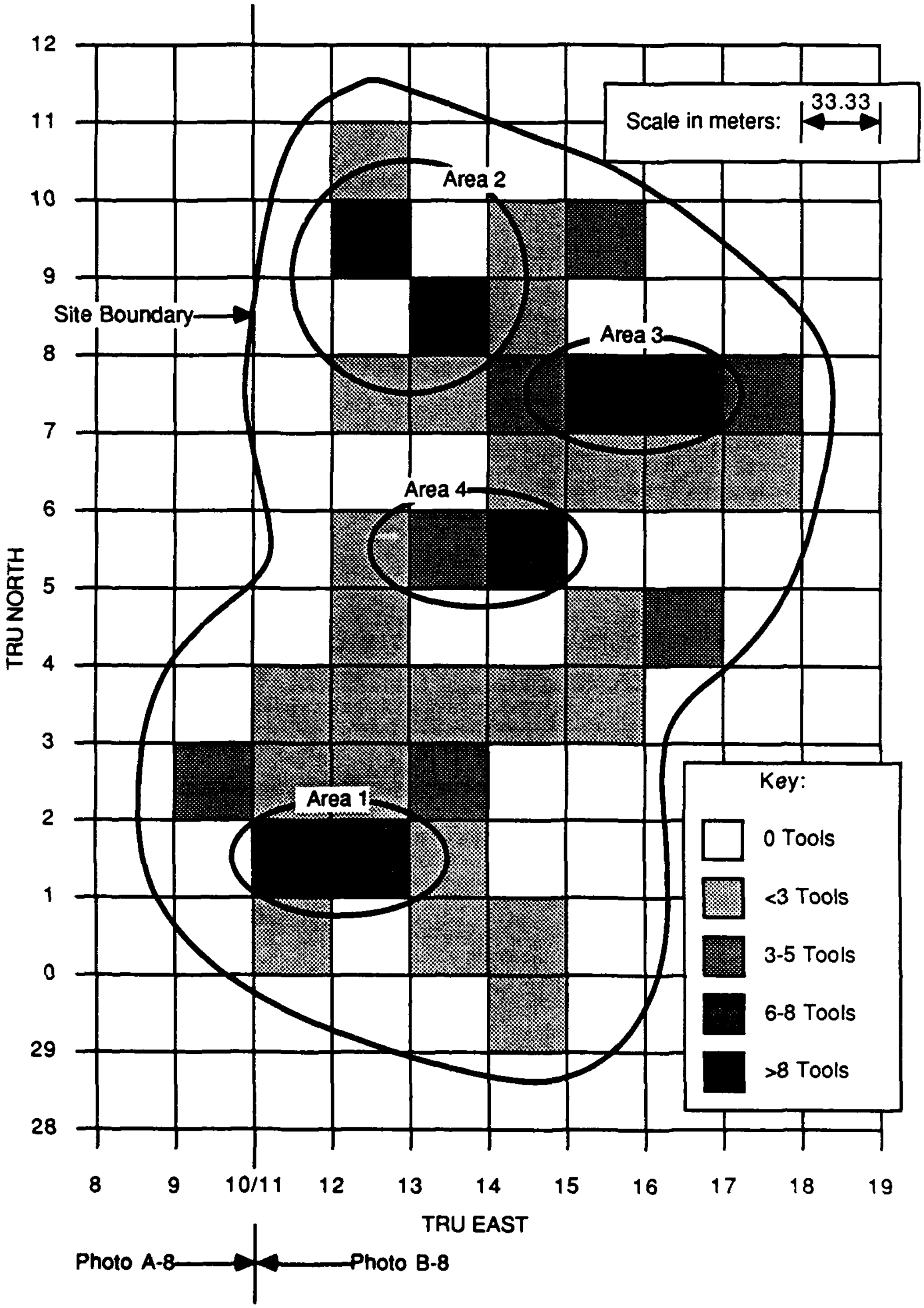


Figure 17.1. LA 63880 tool density

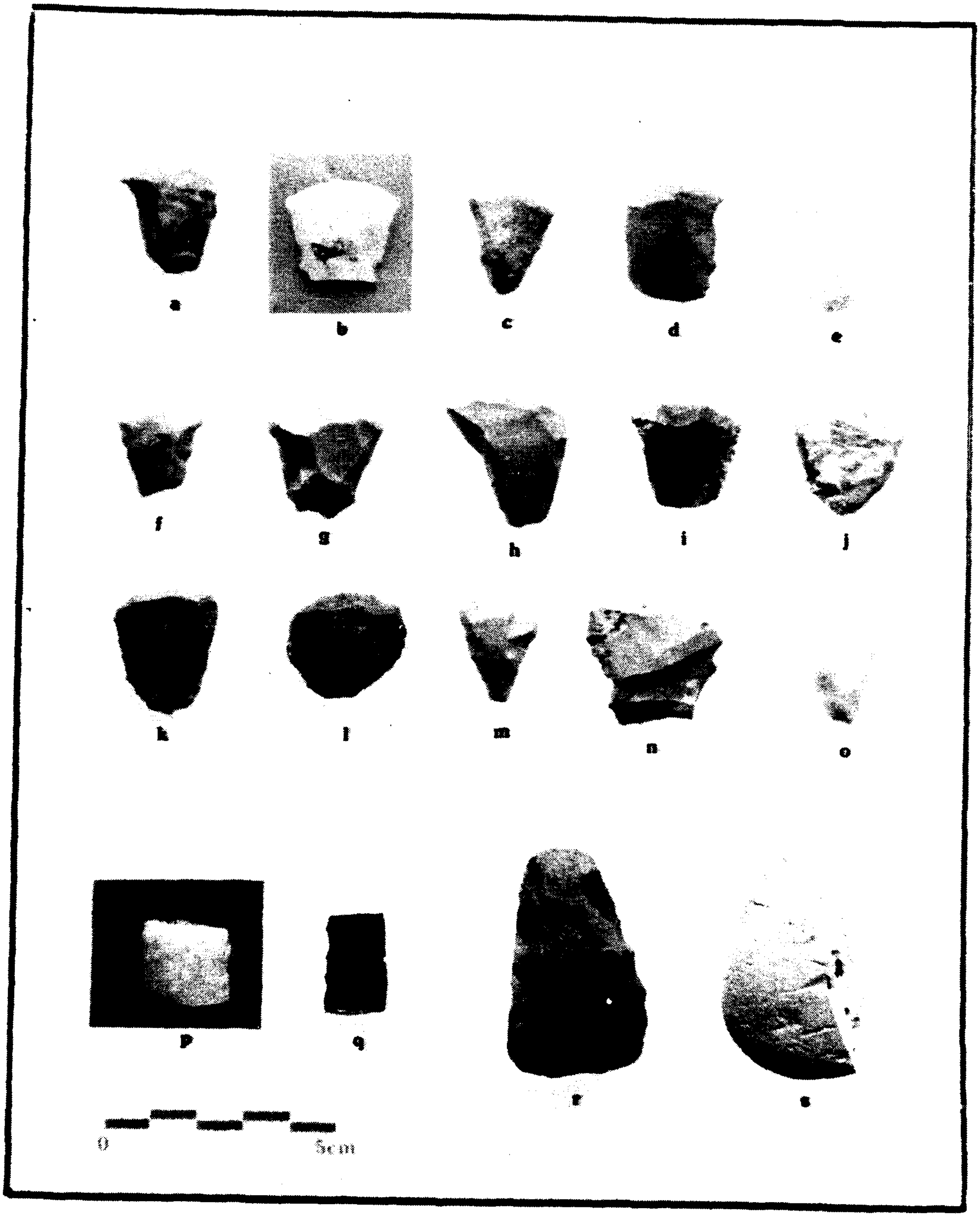


Figure 17.2. Paleoindian tools from LA 63880

Table 17.1. LA 63880 lithic tool assemblage

Type	Number	Percent
Transverse Endscrapers	101	76.5
Left Sidescrapers	12	9.1
Right Sidescrapers	6	4.5
Beaked Scrapers	3	2.3
Retouched Flakes	4	3.0
Bifaces	1	0.8
Projectile Points	2	1.5
Spokeshave	1	0.8
Abrader	1	0.8
Burin Spall	1	0.8
Total	132	100.1

ence of small flakes with well-prepared platforms and well-made transverse endscrapers exhibiting spurs.The fact that most of these artifacts were manufactured from waxy, fine-grained cherts and chalcedonies added to our conviction. In order to test the accuracy of this temporal placement, comparisons with other lithic materials collected during the Phase I survey were performed.Paleoindian tools, lithic material selection, and reduction trajectories are unique in several respects from those of other cultural and temporal periods. Comparisons of LA 63880 artifacts and other site-specific Phase I assemblages were not possible because of the TRU survey strategy, which seldom enabled us to obtain adequate sample sizes from specific sites in firmly dated contexts. We were thus limited to comparing the Paleoindian assemblage with the remainder of the Phase I formal tools treated in their entirety as a single assemblage. It is recognized that the Phase I collections reflect the full range of cultural and temporal affiliations in the Border Star 85 project area, but it is unlikely that other Paleoindian remains contribute significantly to variability in this collection. The comparison between the LA 63880 assemblage and the remainder of the Phase I materials is intended to demonstrate the uniqueness of the former sample within the spectrum of the entire Border Star 85 collections and to demonstrate the diagnostic value of formal tool characteristics.

As a first step, the Phase I collections were inspected for tools and tool attributes thought to be diagnostic of Paleoindian tools that had not been recorded as such during the Phase I survey or the functional tool analysis (Chapter 16). These attributes included the presence of spurs and burins, and the target tool types consist mainly of small transverse endscrapers similar to those found in the LA 63880 assemblage.

The spurs on scrapers may represent graving and boring functions. Gravers, which are common in Paleoindian assemblages from other regions, may be manufactured on small flakes or may occur on scrapers in the form of spurs. Both forms have been identified only in Paleoindian assemblages (Frison 1978). Incising and perforation of bone, wood, and hides have been suggested as possible functions for these tools (Frison and Bradley 1980; Judge 1973). Within the LA 63880 assemblage, gravers are present in the form of spurs on 50 scraping tools. An examination of the general Border Star 85 tool collection indicated that only 6 of 172 scrapers (3.5 percent) exhibited spurs. All of these occurred on small, transverse endscrapers with multiple working edges.

Burination, or the purposeful removal of flakes parallel to a flake or tool edge, may also be a diagnostic feature of Paleoindian assemblages. The sharp, square edges of burin flake spalls are believed to have been used for scraping and cutting tasks (Frison and Bradley 1980) or for resharpening purposes (Frison 1978; Wilmsen and Roberts 1978). Ten (8 percent) of the LA 63880 scrapers exhibited one or more burinated edges, and one spall from a convex scraping edge was present. In the general scraper collection, burinated edges are represented by the removal of the distal portions of two (1.2 percent) of the small, transverse endscrapers.

Comparison of lithic material variability in the LA 63880 and Phase I collections supports the commonly held belief that Paleoindian populations relied on more high-quality, nonlocal sources of raw material than did later groups. Within the LA 63880 collection, all but three tools—a quartzite biface, a basalt projectile point midsection, and a siltstone abrader—were manufactured from high-quality cherts and chalcedonies. In contrast, the majority of Phase I materials represent coarse-grained material types, most of which are locally available. When Warren's material type categories were used (Appendix 4), it was found that certain fine-grained types were observed only in the Paleoindian assemblage. Material type 1054 is exclusive to LA 63880, and types 1072 and 1233 are present in this assemblage in amounts significantly higher than those that characterize the Phase I collections (Table 17.2). Material type 1054 is visually similar to a chalcedony with small black dendritic inclusions commonly found in Middle Rio Grande Valley Paleoindian assemblages. Type 1072, commonly called Chinle chert, also frequently occurs at Paleoindian sites in the Rio Grande Valley. In the Phase I assemblage, the only tools manufactured from types 1072 and 1233 were small scrapers similar to those in the Paleoindian collection; several of these tools exhibited spurs.

Finally, variables recording size were compared for a sample of scrapers from the Border Star Phase I collections and the LA 63880 tools. Only complete tools were used in this (Table 17.3) of this analysis. As shown by the high *t*-values for length, width, and thickness, these results indicate that the LA 63880 scrapers are significantly smaller than those of the Phase I collections at the .01 confidence level (CL).

Comparison with Other Paleoindian Assemblages

The LA 63880 assemblage was compared with the Paleoindian assemblage from Judge's (1973) Rio Grande study (Table 17.4). The comparison indicates that the Border Star 85 Paleoindian materials are shorter and narrower than the Rio Grande artifacts (a difference that is significant at the .01 CL) but the difference in the thickness between the two assemblages is not significant.

The LA 63880 scrapers may be shorter and narrower be-

Table 17.2. Comparison of material types from Border Star 85 Phase I and LA 63880 assemblages

	Material Type									
	1032	1043	1054	1060	1072	1210	1233	1500	1630	1660
Border Star 85 Phase I Collection										
Number	227	33	0	3	1	1	6	7	48	38
Percent	62	9	0	1	0	0	2	2	13	10
LA 63880 Assemblage										
Number	56	2	9	6	10	3	25	1	3	9
Percent	45	2	7	5	8	2	20	1	2	7

Note: See Appendix 4 for definitions of material types.

Table 17.3. Size comparison of complete scrapers

	LA 63880	Border Star 85 Phase I	Pooled s	s of Mean	*t*-Value
Length (mm)	23.8	35.0	10.0	1.3	−8.555
Width (mm)	19.0	25.6	8.1	1.1	−6.208
Thickness (mm)	6.0	9.1	3.0	0.4	−7.810

$df = 234$

Table 17.4. Size comparison of artifacts from Rio Grande Paleoindian and LA 63880 assemblages

	Rio Grande Sites	LA 63880	Pooled s	s of Mean	*t*-Value
Length (mm)	32.5	23.8	6.6	2.4	3.605
Width (mm)	27.2	19.1	5.2	1.9	4.280
Thickness (mm)	7.1	6.0	2.1	0.8	1.316

$df = 234$

cause of resharpening and reuse. The presence of several burinated edges on 10 of the scrapers and the fact that 1 burin spall exhibits a scraping edge are suggestive of attempts at LA 63880 to revitalize tools dulled through use. Modifications, which may have been obscured by resharpening and reuse, would affect the overall lengths and widths of the tools, but they would have had no effect on their thickness.The fact that burination in the Rio Grande assemblages is not reported by Judge (1973) may also account for the size differences observed in the two scraper assemblages.

Judge (1973) and Judge and Dawson (1972) have suggested a basic site typology for Paleoindian settlement, which consists of campsites, kill sites, armament sites, processing sites, and quarry sites. Kill sites and quarry sites represent areas used for special activities that require unique artifact inventories. Paleoindian quarry sites are not expected to contain culturally diagnostic artifacts, and none has been recorded in southwestern New Mexico. Kill sites are expected to contain a higher proportion of projectile points relative to scrapers and other tools than are campsites. Basecamps, processing sites, and armament sites are variants of campsites. Differences among the assemblages characteristic of these various campsite types are evident in the variablity in the physiographic situation of the sites themselves, in the results of wear analysis, and in measures of tool diversity. Since LA 63880 is not located near a major overlook and does not contain high proportions of projectile points and preforms (bifaces), it is not likely that it represents either an armament or a kill site. It is more likely that LA 63880 is a processing site or base camp.

Nine Paleoindian sites recorded south of the survey area may represent armament and processing sites (Carmichael 1983). All of these sites have smaller artifact inventories than does LA 63880; tool frequencies range from 1 to 19 items. Projectile points constitute 100 percent of the tool assemblage at two sites, but at the other sites the proportion of projectile points ranges from 11 to 33 percent of the assemblages, with scrapers making up 54 to 67 percent of the artifact inventories. In contrast, projectile points at LA 63880 are quite rare (1.5 percent) and scrapers account for 90 percent of the assemblage.

The numbers of tool in Judge's (1973) Rio Grande sites (representing three site types) range from 17 to 230 items

with a median of 34. Only two sites have inventories larger than that found in LA 63880 (both are Folsom base camps), and the percentage of projectile points at these sites ranges from 2 to 29 percent while the percentage of scrapers ranges from 15 to 87 percent. Within the Belen and Folsom processing sites, projectile points constitute 3 to 17 percent of the assemblages while scrapers constitute 19 to 87 percent. Similar variations in the percentages of scrapers and points are also apparent in the armament and base camp site types and indicate that the proportions of the two artifact frequencies are not useful as discriminatory criteria. Nevertheless, the large size of the artifact inventory at LA 63880 is rare in the Rio Grande Valley and even more so in the Tularosa Basin/Hueco Bolson. The high percentages of scrapers and low percentages of projectile points are also rare in both areas.

Intrasite Variability

The large size and the high frequency of artifacts at LA 63880 present problems for the interpretation of the site. Since most Paleoindian sites in the Tularosa Basin/Hueco Bolson are much smaller, this site either represents the aggregation of several small bands or it reflects long-term reoccupation.

An examination of the surface artifact distribution (Figure 17.1) suggests the presence of four spatially distinct artifact areas. Since the majority of the area is covered with high coppice dunes, and since artifacts were only present in small, deeply deflated areas, it is not known whether the artifacts exhibit a uniform subsurface distribution. Surficial clusters are at least 33 m apart and in some cases

Table 17.5. Size comparisons among four artifact areas within LA 63880

Variable	Area 1	Area 2	Pooled s	s of Mean	*t*-Value[1]
Length	20.5	22.2	4.3	1.6	−1.104
Width	16.3	17.7	5.0	1.8	−0.759
Thickness	5.4	5.4	1.6	0.6	−0.063

Variable	Area 1	Area 3	Pooled s	s of Mean	*t*-Value[2]
Length	20.5	22.0	4.7	1.7	−0.851
Width	16.3	18.3	5.5	2.0	−1.001
Thickness	5.4	5.7	1.9	0.7	−0.392

Variable	Area 1	Area 4	Pooled s	s of Mean	*t*-Value[3]
Length	20.5	22.2	4.4	1.8	−0.936
Width	16.3	16.9	5.0	2.0	−0.276
Thickness	5.4	6.0	1.9	0.8	−0.761

Variable	Area 2	Area 3	Pooled s	s of Mean	*t*-Value[4]
Length	22.1	22.0	4.4	1.6	0.156
Width	17.7	18.3	4.7	1.7	−0.380
Thickness	5.4	5.7	1.7	0.6	−0.381

Variable	Area 3	Area 4	Pooled s	s of Mean	*t*-Value[5]
Length	22.0	22.0	4.5	1.8	−0.108
Width	18.3	16.9	4.7	1.9	0.742
Thickness	5.7	6.0	1.9	0.8	−0.419

Variable	Area 2	Area 4	Pooled s	s of Mean	*t*-Value[6]
Length	22.2	22.0	4.0	1.6	0.031
Width	17.7	16.9	4.0	1.6	0.484
Thickness	5.4	6.0	1.7	0.7	−0.817

[1] *df* = 28
[2] *df* = 29
[3] *df* = 23
[4] *df* = 29
[5] *df* = 23
[6] *df* = 24

are separated by 100 m. The artifact assemblages within these four clusters exhibit similar tool frequencies and therefore indicate that the uses of the overall site area were similar. Lithic material types also show a uniform distribution across the surface of the site, and no difference is apparent in the sizes of scrapers from the four areas (Table 17.5).

The analysis suggests that spatially separated areas of the site were used for similar activities. It does not indicate whether the site area represents a single event or aggregate site, or several serially occupied site locations. The vast size of the site when compared with sites found in adjacent regions, especially when it is remembered that Paleoindian bands are suggested to have included from 20 to 50 individuals (Wilmsen 1974), would seem to indicate that the site represents reoccupations of a similar functional nature.

Summary

Analyses of formal tools from LA 63880 strongly support a chronological placement in the Paleoindian period. Comparisons with the Phase I tool collection—representing the entire range of human activity in the Border Star 85 project area—suggest that patterns in lithic technology generally accepted as diagnostic of the Paleoindian period are consistent with those that characterize the LA 63880 tool assemblage. Further comparisons with sites of similar age in the Tularosa Basin/Hueco Bolson reported by Carmichael (1983) and with Judge's (1973) Middle Rio Grande sites serve to emphasize the unique nature of this property. LA 63880 represents one of the largest Paleoindian sites yet found in the Tularosa Basin both in terms of assemblage size and areal extent. Based on its extensive size and low tool diversity, it is believed that the site reflects reoccupation involving similar activities over an extended period of time during the Paleoindian period. In light of the overwhelming predominance of small, well-worn scrapers in the assemblage and the apparent emphasis on resharpening of these tools, it seems likely that these activities were repeated throughout the history of the site and were extractive in nature. In terms of Judge's (1973) typology, LA 63880 most likely represents a processing site.

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Appendix 1

SURVEY PROCEDURES

Timothy J. Seaman

Border Star 85 Phase I Survey Guide

The Border Star 85 project area covers 225 quadrats of one square kilometer each. The basic unit of sampling and recording within the quadrats is the 2 m wide by 33¹/₃ m long (TRU). Thirty contiguous TRUs oriented along a north-south axis form a 1 km long transect, and there are 30 such transects within each sq km quadrat; therefore, there are 900 TRUs per sq km. This sampling strategy made possible a 6 percent intensive coverage of the project area.

The crew chiefs walked the center of three parallel 1 km long transects, while crew members simultaneously covered the two outside transects. The crew chiefs were responsible for accurately maintaining the crew's location along the transects and for providing the necessary provenience information when cultural remains were encountered. Crew members were responsible for keeping a 33¹/₃ m interval between themselves and the crew chief as they covered their TRUs.

Crew personnel were responsible for recording all cultural materials both within and adjacent to their TRUs. Cultural items within the TRU were comprehensively inventoried by artifact or feature type in accordance with the prerequisites of the coding forms (Figure A1.1). The collection policies were as follows:

1) All unknown intrusive ceramics
2) All obsidian flakes and artifacts
3) All projectile points
4) All ornaments, shell, and "rare" artifacts
5) Rim sherds found within TRUs ONLY
6) Bifaces and retouched artifacts found within TRUs ONLY

The following information was recorded on the bag for each collected artifact:

BS-85
COLLECTIONS BAG INFO

KM______ E______	N
TRU______ E______	N
CREW #______	INITIALS______
DATE______	TYPE______
COLL #______	SITE #______

The locations of all features and collected artifacts were drawn on the maps provided on the TRU sheets.

Off-transect features were inventoried and described in the same manner as was used for those encountered within the TRUs. The locations of definable features and collected artifacts outside the TRUs were also plotted on the TRU maps. Off-transect artifacts, however, were not intensively analyzed in the field. Artifact concentrations, i.e., those that occur in a localized, readily definable area, such as a potbreak, were listed in the feature portion of the TRU form by material type. The size of artifact concentrations was given rather than an estimate of the number of items present. Artifact scatters, which do not have readily definable boundaries, were also listed by material type on the feature portion of the form. Because by definition the sizes of "scatters" are not readily known, an estimate of the number of items present was recorded. A TRU sheet was completed whenever cultural debris was found next to a TRU unit, even though no artifacts may have been encountered within the TRU itself. TRU data for each square kilometer survey unit were summarized on a coverage sheet to facilitate laboratory definition of site locations (Figure A1.2). The vegetative and topographic data recorded by the crew chiefs for each of the 100 m sq sample units were to be coded on the TRU sheets only if the TRU immediately south of the sampling station contained cultural materials; otherwise these data were recorded on a separate square kilometer coverage sheet (Figure A1.3).

Off-transect forays by crew chiefs and crew members were made only when possible features were briefly visited or diagnostic artifacts were collected. The coverage of the TRUs was the first priority of this project.

Border Star 85 Feature and TRU Codes

FEATURE TYPE: Feature types are assigned two-digit codes.

(01) Ceramic scatter**
(02) Lithic scatter**
(03) Ground stone**
(04) Bone**
(05) Concentrated fire-cracked rock (FCR)
(06) Scattered fire-cracked rock**
(07) Concentrated burned caliche (BC)
(08) Scattered burned caliche**
(09) Concentrated fire-cracked rock and caliche (FCR/BC)
(10) Scattered fire-cracked rock and caliche**
(11) Hearth: discernible configuration of ash plus FCR or BC
(12) Charcoal stain
(13) Pithouse depression
(14) Surface architecture
(15) Bedrock mortar (size = maximum depth)
(16) Historical(nonmilitary)
(17) Other feature(discuss in comments)

All features not marked with "**" are measured to nearest meter along longest dimension.

"concentrated" = discrete; at least one dimension is readily measurable

BORDERSTAR 85 SURVEY T.R.U. Recording Form

SQ. KM.:____E ____N

T.R.U.:__ __ E ___N

DATE__-__-__ PHOTO #____

CREW _ RECORDER __

TIME__ __ CLOUDS _

SITE___

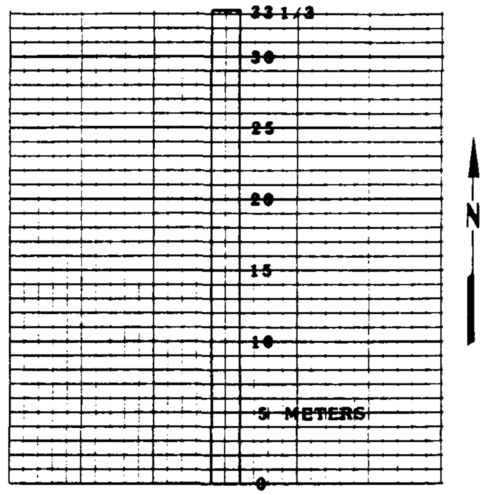
LANDFORM __
(Every 100m)

VEGETATION _-__/_-__/_-__
(Every 100m)

COMMENTS ______________________________

SURFACE CHARACT.
(Each T.R.U.)

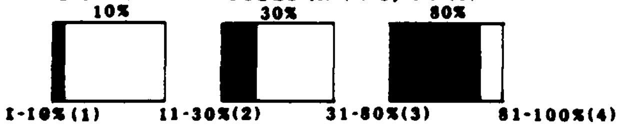
- ☐ Coppice dunes
- ☐ Exposed caliche
- *☐ Playa
- *☐ Grassland area
- ☐ Human alteration
- *☐ Red paleosol
- *☐ Vegetated arroyo
- ☐ Active arroyo
- ☐ Desert pavement
- ☐ Alluvial fan
- ☐ Sheetwash



CERAMICS: TYPE	QUANT.	COLLEC. #	DIRECTION	LITHICS: ARTIFACT TYPE	CONDITION	MATERIAL TYPE	CORTEX	LENGTH	THICKNESS (OR G'STONE WIDTH)	PLATFORM PREP.	PLATFORM ORIENT.	COLLECTED #	DIRECTION

FEATURES: TYPE	SIZE	FEATURE #	DIRECTION

CORTEX CODES IN ( )'S, 0%=(0)



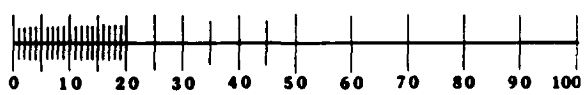


Figure A1.1. TRU recording form

BORDERSTAR-85 ARCHEOLOGICAL SURVEY
COVERAGE SHEET

KM2 _ _ _ E _ _ _ _ N

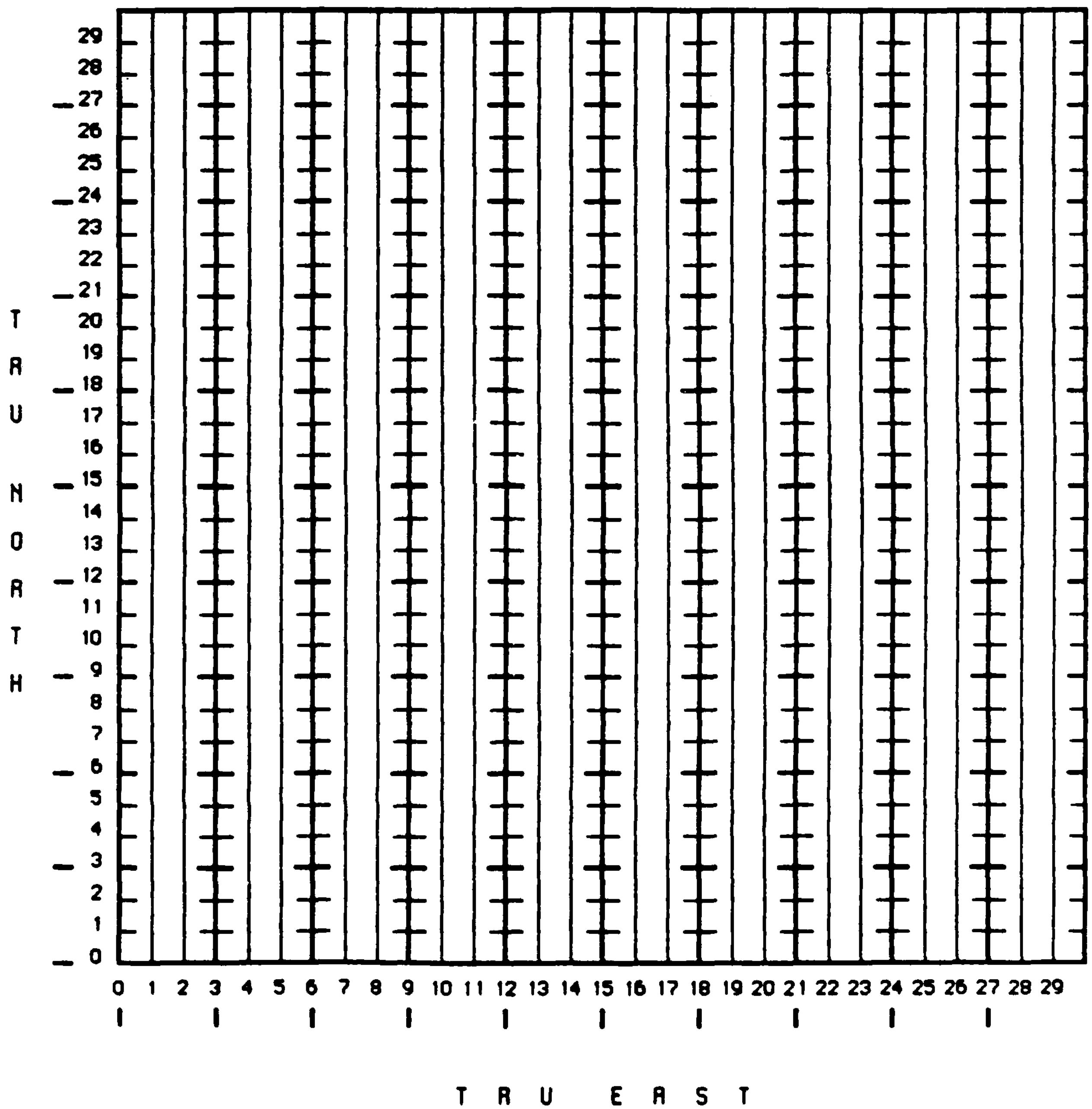


Figure A1.2. TRU square kilometer coverage sheet

BORDER STAR 85 SURVEY

KM^2 ___ ___ ___ E ___ ___ ___ ___ N PHOTO # ___ ___ ___ PAGE 1 OF 2

EASTING	NORTHING		
0	0	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	3	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	6	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	9	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	12	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	15	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	18	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	21	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	24	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	27	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
3	0	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	3	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	6	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	9	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	12	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	15	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	18	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	21	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	24	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	27	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
6	0	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	3	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	6	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	9	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	12	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	15	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	18	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	21	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	24	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	27	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
9	0	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	3	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	6	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	9	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	12	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	15	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	18	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	21	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	24	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	27	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
12	0	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	3	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	6	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	9	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	12	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	15	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	18	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	21	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	24	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___
	27	LANDFORM ___ ___	VEGETATION ___-___ ___/___-___ ___/___-___ ___

Figure A1.3. Topographic and vegetative square kilometer coverage sheet

"scattered" = a diffuse distribution

** Use count estimate:

(-1) 1 to 10 items
(-2) 11 to 30 items
(-3) 31 to 100 items
(-4) +101 items

LENGTH/THICKNESS: In mm (see bottom of TRU form); for all lithics; round to nearest 10 mm for all artifacts greater than 10 cm.

Flake length is measured perpendicular to the platform (striking direction); for all other artifacts length is the longest dimension. Length and width (thickness) are measured for whole metate and mano grinding surfaces (use the largest surface on multiface manos).

DIRECTION (same for Lithic and Ceramic off-transect collections):

(E) East of transect
(W) West of transect
(O) On transect

(NOTE: Code one "E" and one "W" for scatters lying on *both* sides of transect.)

COLLECTION # (Lithics and Ceramics): A unique identifying number for collected artifacts numbered sequentially within each TRU and artifact class. Keyed to the TRU map.

FEATURE #: A unique number assigned to each feature identified during survey of a TRU. Used for features (e.g., hearths, pithouse depressions, charcoal stains) and concentrations of fire-cracked rock and/or caliche. Keyed to the TRU map.

SIZE: Measurement (in meters) of recorded features. Use largest horizontal dimension or depth for bedrock mortars.

SQ KM: UTM easting (3 digits) and northing (4 digits) of SW corner of sq km quadrat.

TRU: Transect Recording Unit referenced by its east and north coordinates within a sq km quadrat; coordinates can be calculated by multiplying its east and north coordinates by 33.33 and then adding this figure to the Sq Km UTM coordinates (see Sq Km recording form).

PHOTO #: Alpha-numeric designation of the aerial photograph used in surveying a TRU.

RECORDER: Initials (2 letters) of the surveyor recording a TRU.

CREW: Numeric designation of crew surveying a series of TRU transects. Crew numbers were assigned to each crew chief as follows:

1) Sanders
2) Rugge
3) Anschuetz
4) Elyea
5) Eschman
6) O'Hara

DATE: The date on which a TRU was surveyed; coded as DD/MM/YY.

TIME: The time to the nearest half hour when the TRU was surveyed.

CLOUD: Simple code (yes or no) indicating the presence or absence of direct sunlight on a TRU during survey.

SITE?: Subjective assessment indicating the likelihood that the surveyed TRU and adjacent area are part of an archeological site. Coded as "yes" or "no." Based on features and artifacts observed from the TRU.

COMMENTS: Open field for notes supplementing coded information on cultural and environmental characteristics of the TRU. Also used for artifact tallies during recording and for noting the presence of explosive ordinance for disposal by EOD.

TRU MAP: Use this schematic representation of the TRU and adjacent areas to indicate the provenience of collected artifacts and recorded features.

SURFACE CHARACTERISTICS: Check the box or boxes most appropriate to the surface characteristic of the TRU.

CORTEX % TEMPLATE: Use these figures to estimate the percent of dorsal cortex on flakes and total cortex on cores. Each shaded figure marks a "break point" between classes.

Border Star 85 Lithic Codes

ARTIFACT TYPE

Debitage

(01) ANGULAR DEBRIS	Dorsal and ventral surfaces indistinguishable
(02) FLAKE	Dorsal and ventral surfaces distinguishable
(03) BIFACIAL FLAKE	Thinning flake (curved, thin, prepared platform)
(04) SHARPENING FLAKE	Small, thin, may be pressure flake

Cores

(10) TESTED ROCK	Two or less than two flakes removed
(11) IRREGULAR CORE	"Catch-all" core category
(12) BIDIRECTIONAL CORE	More than 3 cm thick
(13) BLADE/ UNIDIRECTIONAL CORE (chopper)	Single large platform
(14) TABULAR BLANK	Occurs naturally in tabular form

Tools

(20) HAMMERSTONE	Cobble with battered end and/or side (*not* core)
(21) ANVIL STONE	Manuport with battered surface
(22) RETOUCHED ANGULAR DEBRIS	Retouch scars at least 2 mm long, consistent pattern
(23) RETOUCHED FLAKE	Retouch scars at least 2 mm long, consistent pattern
(24) PROJECTILE POINT	
(25) BIFACE (knife)	Less than 3 cm thick
(26) UNIFACE (scraper)	Predominantly unidirectional retouch

(27) DRILL (graver)	Retouched projection (pronounced)
(28) SPOKESHAVE	Retouched concavity (pronounced)

Ground Stone

(40) UNKNOWN GROUND STONE	Indeterminate ground stone fragments
(41) MANO (UNK)	Indeterminate mano fragment
(42) ONE-HAND MANO	(or ground cobble)
(43) TWO-HAND MANO	
(44) METATE (UNK)	Indeterminate metate fragment
(45) SLAB METATE	Relatively flat grinding surface
(46) BASIN METATE	Concave grinding surface (both dimensions)
(47) BOULDER MORTAR	
(48) TROUGH METATE	
(49) GROOVED SANDSTONE	
(50) MANUPORT	Unmodified stone not in natural setting
(51) OTHER	Indeterminate—*use sparingly*

CONDITION (see guide)

(1) UNKNOWN FRAGMENT (all angular debris)
(2) PROXIMAL
(3) MEDIAL
(4) DISTAL
(5) LATERAL
(6) COMPLETE
(7) USED (cores only)
(8) BURNED (all artifacts)

PLATFORM TYPE (Figure A1.4)

(1) COLLAPSED
(2) CORTICAL
(3) SINGLE FACET
(4) MULTIFACET
(5) PREPARED (retouched, stepped, or ground)

PLATFORM ORIENTATION (Figure A1.5)

(1) perpendicular to long axis
(2) oblique to long axis
(3) parallel to long axis

MATERIAL TYPE

(01) CHERT—WAXY/VITREOUS
(02) CHERT—DULL
(03) CHALCEDONY
(04) SILICIFIED WOOD
(05) QUARTZITE
(06) OBSIDIAN
(07) BASALT
(08) RHYOLITE
(09) SANDSTONE
(10) GRANITE
(11) VOLCANIC PORPHYRY
(12) CARBONATES
(13) OTHER

CORTEX (see bottom of TRU form)

(0) 0% "None"
(1) 1–10% "Smidge"
(2) 11–30% "Some"
(3) 31–80% "Lots"
(4) 81–100% "Like totally cortex"

Border Star 85 Ceramic Codes

CERAMIC TYPE (Figure A1.6)

(01) Unspecific brown
(02) Other plain brown
(03) San Francisco Red
(04) Mogollon Red-on-brown
(05) Three Circle Red-on-white
(06) Mimbres Black-on-white Style I
(07) Mimbres Black-on-white Style II
(08) Mimbres Black-on-white Style III
(09) Mimbres Black-on-white truly indeterminate
(10) El Paso Bichrome
(11) El Paso Polychrome
(12) Chupadero Black-on-white
(13) Playas Red
(14) Red-on-terracotta
(15) Lincoln Black-on-red
(16) Mexican Polychrome
(17) White Mountain Redware
(18) Cibola Whiteware
(19) Gila polychrome
(20) Carbon-painted black-on-white
(25) Corrugated
(26) Textured
(27) Smudged
(50) Unknown

Border Star 85 Environmental Codes

VEGETATION

(1) Grasses
(2) Mesquite
(3) Creosotebush
(4) Sagebrush
(5) Saltbush
(6) Snakeweed
(7) Tarbush
(8) Other (specify in comments)
(9) Absent

TOPOGRAPHY

(01) Low coppice dunes	Mesquite—capped dunes < 2 m high
(02) High coppice dunes	Mesquite—capped dunes > 2 m high
(03) Continuous semistabilized dune	Low profile, few/small blowouts
(04) Stabilized true dune	Large, vegetated eolian feature
(05) Active true dune	(Mostly) unvegetated eolian feature
(06) Playa	
(07) Arroyo/wash	
(08) Alluvial fan	ca. 1–5 degree slope
(09) Ridge	Pronounced topography
(10) Low rise	Gentle topography
(11) Creosote flats	
(12) Terrace	
(13) Mountain front/foothill	
(14) Base of talus slope	
(15) Talus slope	
(16) Other	

Border Star 85 Phase II Survey Guide

Goals

In addition to the research questions concerning Paleoindian, Archaic, and Formative period settlement/subsis-

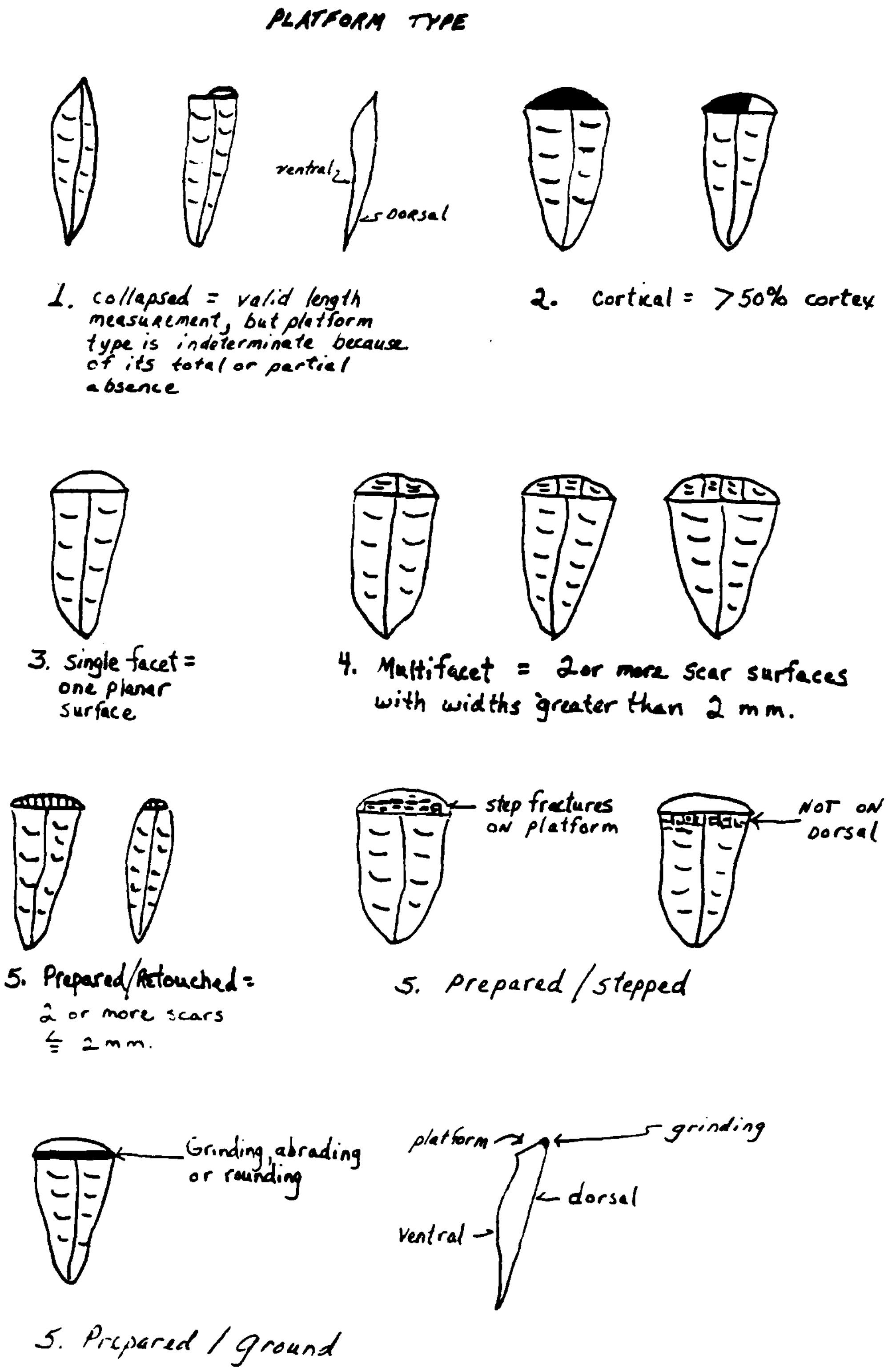


Figure A1.4. Platform type attributes

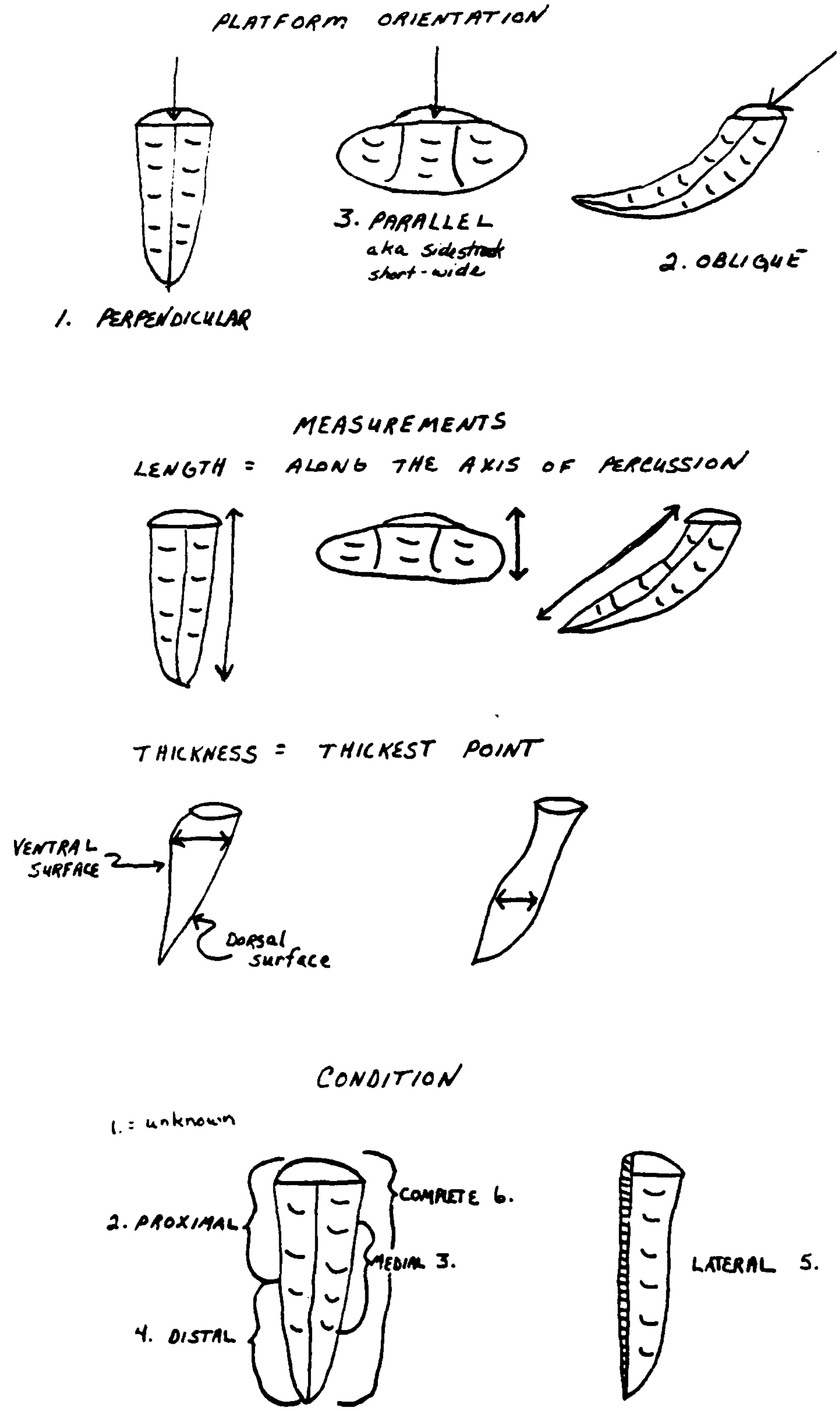


Figure A1.5. Platform orientation attributes

APPENDIX 1

BORDERSTAR-85 CERAMICS PHASE I FIELD SHEET

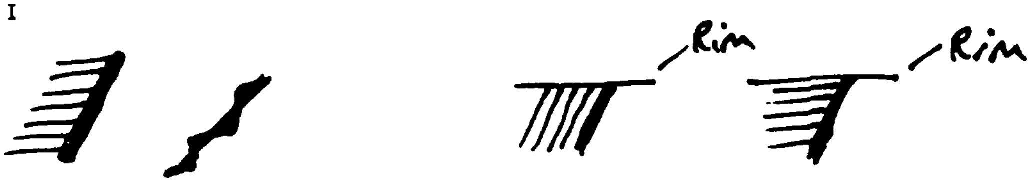
Unspecific brown --- "popcorn" temper

El Paso Series --- "popcorn" temper
--- Bichrome is Black-on-brown
--- Polychrome is Black and Red on brown

Mimbres B/W design elements

STYLE I

STYLE II



STYLE III

Mimbres B/W --- often misfired to Black-on-red
--- NO crackling
--- NO scoring

Chupadero B/W --- crackled and scored, grey slip.

PICK UP THE FOLLOWING SHERDS

ALL rims
ALL unknowns and questionable types
ALL Black-on-reds that are NOT El Paso Polychrome

THERE IS A TYPE COLLECTION IN THE FIELD CAMP - PLEASE USE IT.

Figure A1.6. Field guide for ceramic types

tence, Phase II of the Border Star 85 survey gathered data to assess the effective resolution of the 33.33 m transecting methodology utilized in Phase I and its relative accuracy for estimating the cultural content of a variety of landscape types, including site locations. In this regard, Phase II goals were oriented toward understanding the limitations and the potential of the Phase I data. The results of Phase II studies provided a sound basis for evaluating and designing similar landscape sampling methodologies and for addressing the overall project analytical objectives using both Phase I and Phase II data.

Data were collected in order to answer the following questions:

1) At what "size threshold" do transect-based estimates of overall site content become reliable?
2) What is the effect of internal spatial structure at various scales on estimates of site content? This is especially critical on larger sites.
3) What do low-density (i.e., "nonsite") areas really look like, and to what degree were site boundaries poorly defined or even missed?
4) To what degree do the Phase I data accurately represent the landscape as one consisting of "hot spots" and intervening low-density areas, as suggested by the preliminary density plots?

Phase II Survey Units

Considering the problem of site boundary definition (and, ultimately, assemblage definition) and the questions regarding effective resolution raised by the Phase I survey, it was believed appropriate to consider portions of the cultural landscape—rather than sites—as the basic unit for intensive survey during Phase II. Although an exception was made for the extremely dense intrasite distributions found in the Monte Carlo Gap area, where a 100 by 100 m unit (1 ha) was used, landscape units measuring 500 by 500 m (25 ha) were viewed as sufficient for addressing these problems.

Phase II survey units were chosen on the basis of a cluster analysis of Phase I survey results for all 500 by 500 m units within Area A. The variables utilized in this analysis consisted of factors that are relevant to resolution and sampling problems raised by the Phase I survey methods. These variables are basic measures of the density and spatial distribution of materials on the cultural landscape (e.g., degree and frequency of clustering of cultural material, overall density of cultural material). An attempt was made to choose units that, as a group, provide a representative sample of the range of variability in the cultural landscape as revealed by the cluster analysis.

With the exception of the one hectare in Monte Carlo Gap, the choice of specific units from the different clusters for Phase II was guided by two additional considerations:

1) Environmental setting. Units chosen include representatives from the Monte Carlo Gap area (high alluvial fans), the low alluvial fans surrounding the mountain base, and the basin proper.
2) Cultural period. Both ceramic and aceramic landscapes and sites, as well as at least one known Archaic site, are represented in the priority 1 level sample units.

Data Collection Methods

The methodological questions addressed as part of Phase II survey required that data collection procedures be focused on gaining a 100 percent sample of cultural remains from each selected survey unit and that Phase II data be quantitatively and qualitatively comparable to the Phase I data base. The basic unit of spatial control during data recording was the 2 by 2 m square identified by its grid coordinates within each survey unit. Phase II survey is organized in two major survey stages.

Discovery Stage. This stage identified all cultural materials and features within the survey units and recorded those remains amenable to point proveniencing on the 1:750 scale photo enlargements (Figure A1.7, A1.8). In this stage, the previously marked survey units were covered by a three-person crew starting at the southwest corner of the unit. Crew spacing was no more than 5 m apart and the crew chief, who was responsible for orienting the crew using the aerial photos, walked between the two crew members. The easternmost surveyor used biodegradable flagging tape (TP) to ensure full coverage. Decisions on recording/point proveniencing vs flagging artifacts and features were guided by the spatial distribution and density of the cultural remains. If artifacts/features, either isolated or in scattered small concentrations (within a radius of ca. 2.8 m) be accurately plotted on the photo, recording was done during this survey stage and no flagging was required. Flagging was left in the field only to mark hearths or stains that might contain datable charcoal as indicated by trowel tests or surface observation. It should be noted that more than one artifact/feature could be given the same provenience (and map number) if it was isolated within an area of ca. 2.8 m (the diagonal of a 2 by 2 m unit) and no other concentrations were located within ca. 2.8 m of its outer limits. These points were converted to grid unit proveniences in the lab prior to data entry.

If cultural materials were too dense to allow plotting on the photos, artifacts and features were flagged as follows:

1) Ceramics (orange)
2) Lithics (blue)
3) Fire-cracked rock/burned caliche (red)
4) Hearths, charcoal stains (yellow flags)

The limits of such concentrations were accurately plotted on the photos along with relevant topographic and environmental features (e.g., drainage patterns, vegetative anomalies, playa locations, and recent physical disturbances) for the entire survey unit. When the remains of isolated cultural features that contain evidence for the use of fire were encountered, very brief trowel tests were made and notes were taken for those believed to contain datable charcoal samples.

Recording Stage. This second stage of survey focused on the controlled recording of artifact/feature concentrations identified during the discovery stage. Depending on the density of cultural material, three- or four-person crews relocated and systematically recorded these concentrations using a movable system of 2 by 2 m grid units. *Only* previously flagged artifacts/features were recorded during this phase to minimize bias introduced by surface disturbance during the initial discovery phase (i.e., new discoveries were ignored).

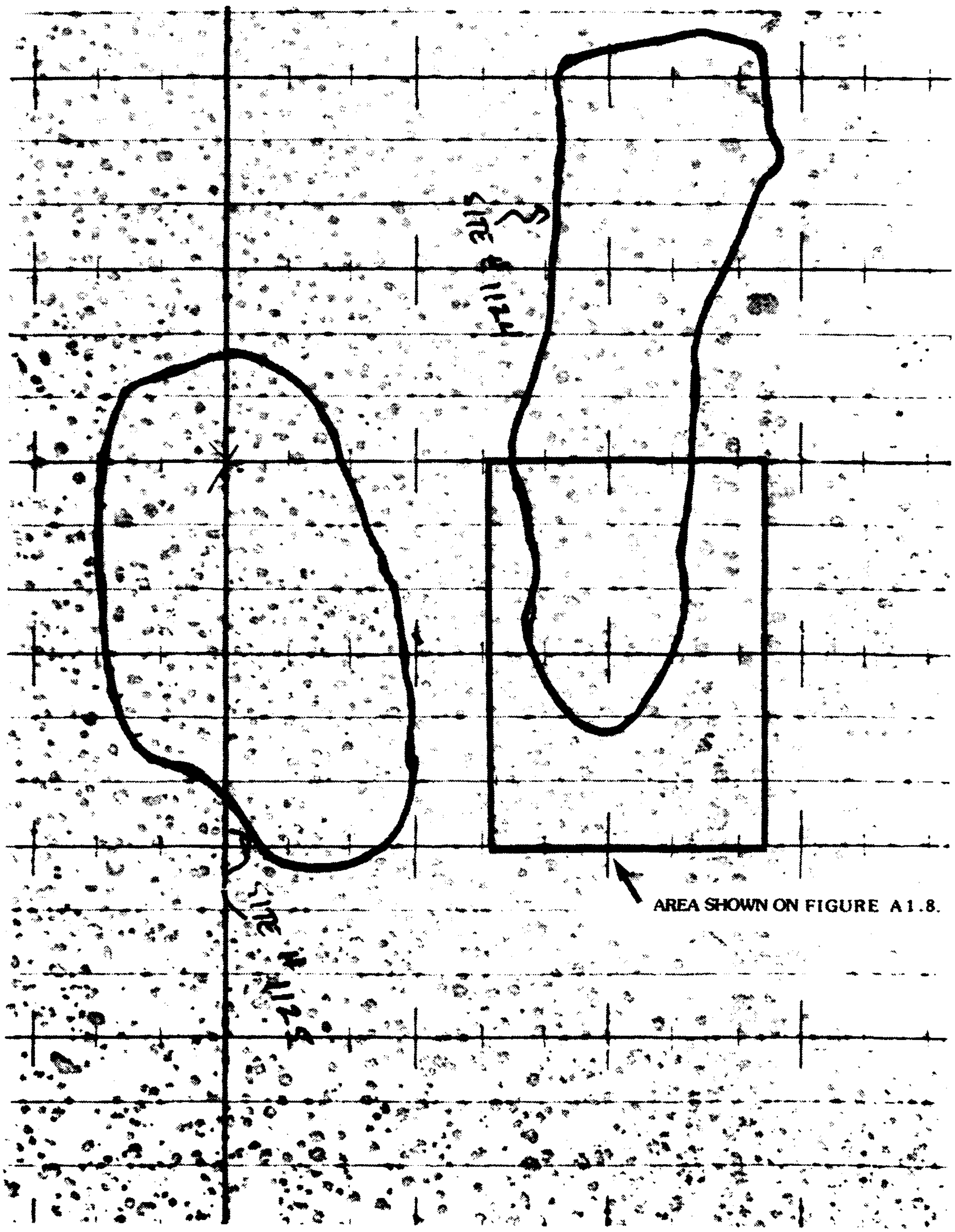


Figure A1.7. Example of Phase I 1:3000 scale imagery

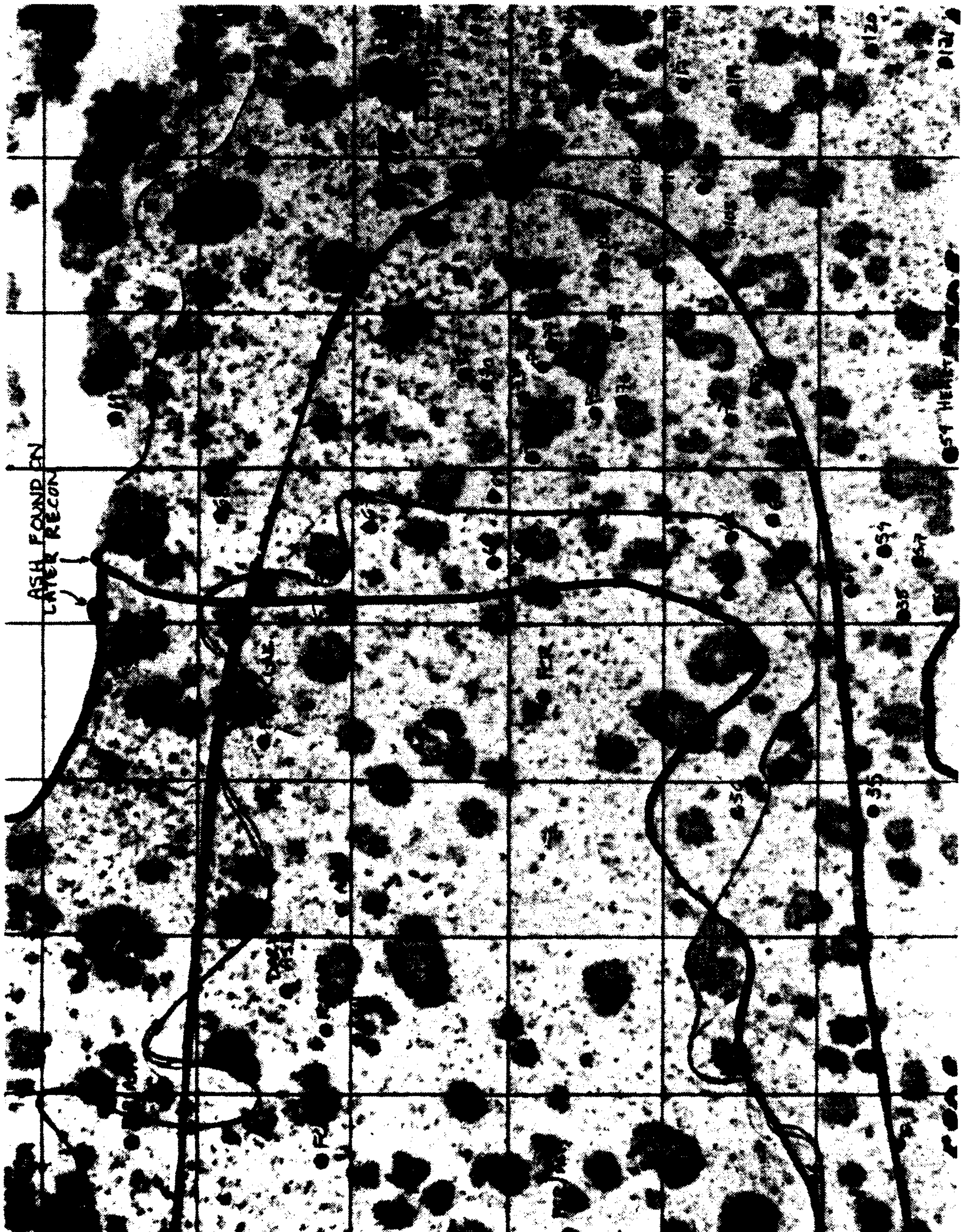


Figure A1.8. Example of Phase II 1:750 scale imagery

Briefly, this recording method utilized four measuring tapes or partitioned ropes to record material within a series of 2 by 2 m units without actually surveying in and staking those units. A brief pre-field training session was conducted (with plenty of time devoted to questions and criticisms) to familiarize the crews with this process.

A third data collection stage involved an additional 2- or 3-person crew for the purpose of collecting radiocarbon samples from the previously identified hearth-related features in each survey unit.

In general, data recording procedures were identical to those used in the Phase I survey. The major differences in Phase II recording included:

1) different data recording units (i.e., 2 × 2 m units versus 2 × 33.33 m TRUs on Phase I),
2) counting—rather than estimating—fire-cracked rock and burned caliche as part of feature recording (see coding guide),
3) systematic mapping and, in some cases, trowel and auger testing (for datable carbon samples) of well-defined hearths and fire-cracked rock concentrations after recording on the photo enlargements, and
4) systematic mapping of relevant environmental features (e.g., drainage patterns and vegetative anomalies), and defined site boundaries on the photo enlargements.

A new recording form developed for Phase II survey is attached, along with specific variable definitions and coding conventions. These forms have been maintained in a file for each survey unit (sorted by date) along with collected artifacts.

Collection policies were identical to those guiding Phase I survey. The following items were collected:

1) Unknown intrusive ceramics
2) Rim sherds of all types
3) Obsidian flakes and tools
4) Projectile points
5) Bifaces and retouched artifacts
6) Ornaments, shell, and "rare" artifacts

Collections data duplicate the clerical and provenience information on the recording form. Collection numbers were assigned in the field to each collected item, but only one collection bag was used per 2 by 2 m unit. Individual artifacts—with consecutive collection numbers—were bagged separately within the unit bag, and only their collection numbers and artifact types were recorded on these artifacts. The following information was recorded on collection bags (see the attached coding guide for specific instructions on these variables):

1) Date (DD/MM/YY)
2) Recorder (initials)
3) Survey unit (KME/KMN)
4) Grid coordinates (GRIDE/GRIDN)
5) Collection numbers of items within bag (1–n)

Survey Procedures

Variable/Code Definitions (Figure A1.9)

CLERICAL DATA

UNIT: Survey unit designation; km coordinates of southwest corner of unit (e.g., 385E/3594.5N, 391.5E/3592N, etc.).

DATE: Date of recording (DD/MM/YY).

RECORDER: Recorder's initials.

MAPNO: Map number for isolated (plotted) artifacts/features; numbered from 1 to n within each survey unit; do not code UTME or UTMN for artifacts/features assigned a MAPNO. These will be digitized prior to data entry.

GRIDE/GRIDN: Coordinates of 2 by 2 m recording grid within survey unit, ranging from 0 to 498 E and 0 to 498 N (e.g., 268E/342N, 004E/016N); UTM coordinates will be computed as (UNITEx1000) + GRIDE and (UNITN x1000) + GRIDN.

CERAMIC DATA

CERAMIC TYPE: Ceramic types were assigned two-digit codes.

(01) Unspecific brown
(02) Other plain brown
(03) San Francisco red
(04) Mogollon Red-on-brown
(05) Three Circle Red-on-white
(06) Mimbres Black-on-white: Style I
(07) Mimbres Black-on-white: Style II
(08) Mimbres Black-on-white: Style III
(09) Mimbres Black-on-white: Truly Indeterminate
(10) El Paso Bichrome
(11) El Paso Polychrome
(12) Chupadero Black-on-white
(13) Playas Red
(14) Red-on-terracotta
(15) Lincoln Black-on-red
(16) Mexican Polychrome
(17) White Mountain Redware
(18) Cibola Whiteware
(19) Gila Polychrome
(20) Carbon paint Black-on-white
(25) Corrugated
(26) Textured
(27) Smudged
(28) Slipped redwares
(50) Unknown

VESL: Vessel form code—recorded for rim sherds only.

B Bowl sherd
J Jar sherd
I Indeterminate sherd

NO: Number of sherds of TYPE "nn" and VESL "x" within 2 X 2 m unit or associated with provenienced MAPNO.

LITHIC DATA

LITHIC TYPE: Lithic types were assigned two-digit codes.

Debitage

(01) Angular Debris (ventral/dorsal surface not distinguished)
(02) Flake (can distinguish ventral/dorsal surface)
(03) Bifacial Flake (biface thinning; curved, thin, prepared platform)
(04) Sharpening Flake (small, thin, may be pressure)

BORDERSTAR 85 PHASE II SURVEY

UNIT______ DATE______ RECORDER______

LOCATION			CERAMICS			LITHICS							FEATURES	
MAPNO	GRIDE	GRIDN	TYPE	VESL	NO	TYPE	COND	MATL	CRTX	LENGTH	THICK	PLPREP	TYPE	#FCR

BORDERSTAR Form 1, 1 Jun 85
ONE-TIME

Figure A1.9. Phase II survey code sheet

Cores

(10) Tested Rock (<2 flakes removed)
(11) Irregular Core ("catchall" core category)
(12) Bifacial Core/Chopper (τ3 cm thick)
(13) Blade/Unidirectional Core (single large platform)
(14) Tabular Blank (occurs naturally in tabular form)

Tools

(20) Hammerstone (cobble with battered end/side—not core)
(21) Anvil Stone (manuport with battered surface)
(22) Retouched Angular Debris (retouch scars τ2 mm, consistent pattern)
(23) Retouched Flake (retouch scars τ2 mm, consistent pattern)
(24) Projectile Point
(25) Biface/Knife (<3 cm thick)
(26) Uniface/Scaper (predominantly unidirectional retouch)
(27) Drill/Graver (retouched projection—pronounced)
(28) Spokeshave (retouched concavity—pronounced)

Ground Stone

(40) Unknown Ground Stone (indeterminate groundstone fragment)
(41) Mano—unknown (indeterminate mano fragment)
(42) One-hand Mano
(43) Two-hand Mano
(44) Metate—unknown (indeterminate mano fragment)
(45) Slab Metate (flat grinding surface)
(46) Basin Metate (concave grinding surface)
(47) Boulder Mortar
(48) Trough Metate
(49) Grooved Sandstone, etc.
(50) Manuport (unmodified stone not in natural setting)
(51) Other (indeterminate—use sparingly)

COND: Condition or completeness of artifact (see illustrations).

(01) Unknown Fragment (all angular debris)
(02) Proximal
(03) Medial
(04) Distal
(05) Lateral
(06) Complete
(07) Used (cores only)
(08) Burned (all artifacts)

MATL: Lithic material type.

(01) Chert—waxy/vitreous
(02) Chert—dull
(03) Chalcedony
(04) Silicified Wood
(05) Quartzite
(06) Obsidian
(07) Basalt
(08) Rhyolite
(09) Sandstone
(10) Granite
(11) Volcanic Porphyry
(12) Carbonates
(13) Other

CORTEX: Percent cortex class.

(00) 0% ("none")
(01) 1–10% ("smidge")
(02) 11–30% ("some")
(03) 31–80% ("lots")
(04) 81–100% ("like totally cortex")

LENGTH/THICKNESS: Length/thickness in mm; round to nearest 10 mm for artifacts τ10 mm; code grinding surface width (largest grinding surface for multi-face manos) in place of thickness for ground stone; for flakes, length is measured perpendicular to the platform—otherwise measure longest dimension.

PLPREP: Platform preparation class (Figure A1.4).

(01) Collapsed
(02) Cortical
(03) Single Facet
(04) Multifacet
(05) Prepared (retouched, stepped, ground)

FEATURE TYPE: Feature types were assigned two-digit codes.

(05) Concentrated Fire-Cracked Rock/Burned Caliche (discernible configuration)
(06) Scattered Fire-Cracked Rock/Burned Caliche (no discernible configuration)
(12) Charcoal Stain (discrete)
(13) Pithouse Depression
(14) Surface Architecture
(16) Historic (nonmilitary)
(17) Other

FCR: Count of fire-cracked rock/burned caliche fragments (>3 cm) within 2×2 m unit or associated with provenienced MAPNO.

COLL: Number assigned to each collected artifact within a 2×2 m unit (i.e., 1 to n).

Appendix 2

BORDER STAR 85 DATA PROCESSING GUIDELINES

William H. Doleman

Introduction

This Appendix contains a brief description of the dBASE II input and data management program used for Phase I of the Border Star 85 archeological project, and its relationship to the field methods described in Chapter 2. Included are copies of all related source code modules (dBASE II Ver. 2.43* is a product of Ashton Tate, copyright 1984.) The attached materials include a general description of two program packages, one for data entry (the Border Star 85 Input Program Document), and one for data summary ("SUMMARY.CMD"). Also included are source codes for both programs, and copies of the relevant dBASE II "STRUs" (data base formats or structures). Source code for all programs is included in the microfiche packet.

The dBASE II system included in this document represents the first attempt by OCA to use dBASE II to input, manage, and report data from a major project. The programs are in some places rather awkward in organization, and later applications written by OCA are more sophisticated in their use of the potentials of dBASE II. Nonetheless, the use—demonstrated here—of the dBASE II indexing and MACRO variable functions (among other things) is indicative of how versatile dBASE II is and how appropriate it is for applications in archeology. OCA reviewed several data base management packages but chose dBASE because of its greater flexibility and ease of use. Another reason is that SAS running on microcomputers (PC SAS, copyright, SAS Institute, 1987) easily imports dBASE II files for analysis.

Before the Border Star 85 survey, data acquisition at OCA usually consisted of several time-consuming activities. First, artifacts (for example) were analyzed and the results coded on analysis forms. These data were then transferred to FORTRAN coding sheets and entered into raw mainframe data files using a rudimentary text editor. Finally, these raw data were imported into the mainframe version of SAS using custom-written input programs. This method cost more money and—perhaps more importantly, more time—because of high error rates, high log-on time costs, and slow data entry. A rough estimate is that the use of customized dBASE data entry systems on microcomputers saves at least 50 percent over conventional data entry costs.

Recent use of this latter approach has allowed OCA to improve the quality of research by saving money normally devoted to tasks such as proofreading data. Though not documented here, the Phase II input programs were based on more screen-oriented applications (where screen input mimics paper field forms), linked/indexed file processing, and user-transparent error-checking.

The Border Star 85 survey was conducted over a period of four months in late 1984 and early 1985. The survey procedures were designed to reflect recent changes in the perspective on the nature and reality of sites in the traditional sense. The fieldwork was conducted in a 225 sq km area of the southern Tularosa Basin on the west side of the Jarilla Mountains. Two meter-wide transects called TRUs (Transect Recording Units) spaced 33¹/₃ m apart were laid out across the entire area (900 TRUs per sq km). Locational control was maintained by 1:3000 scale aerial photographic enlargements with the TRU grid system (aligned with the USGS UTM coordinate system) overlaid on them. All cultural materials encountered (lithics, ceramics, and hearth features for the most part) were recorded on TRU forms designed at OCA. Vegetative data were collected at 100 m intervals. "Sites" were defined in the field when possible, or in the field office when large areas of intermittent or continuous remains were encountered. Specific survey methods and coding procedures are described in Chapter 2 and Appendix 1.

The goal of the survey methods was to create a data base that contained both typical survey data in terms of sites and isolates and modern, nonsite data in the form of information on the artifact and feature content of the cultural landscape. The latter data were intended to constitute a remotely-sensed image of the survey area with TRUs representing pixels. The various kinds of data recorded (including "siteness") thus make the resulting image a multispectral one, which can be mapped in a variety of ways and at a variety of scales from 33¹/₃ m up. Actually, the calibration of the Phase I data presented in Chapters 5 and 6 indicates that the minimum sampling resolution of the data is more on the order of 250–500 m or more, as a result of the fact that the TRU data are only samples of their pixels.

The data entry system described below used TRUs and square kilometers as the basic units of organization. All data from 1 sq km were entered into a set of related files referred to as a "batch." In all, there were some 239 batches entered because some partial square kilometers were incompletely surveyed. These data occupied some 35 DS/DD diskettes or about 5–7 mb. Following entry and editing, the data were uploaded to the University of New Mexico IBM mainframe for analysis. A similar system was used for data entry in the second project phase.

The functional relationships among the dBASE command files that comprise the input program package are discussed below. Each of the attached source code files contains a descriptive header. Some source code files contain marginal comments describing the internal workings of the program (see INPUT.CMD); these comments would

have to be deleted prior to running the program. The programs developed by OCA are the property of the U.S. Government. Disk copies of the source code can be made available on request provided permission is obtained from the Ft. Worth District Army Corps of Engineers, and interested parties should feel free to play with the program and to give copies to other interested persons ("ARMY.CMD," for example, is a graphic which was written to entertain data entry personnel and combine the functions of "TANK" and "BOMB").

Entry of the TRU data is guided entirely by the INPUT command file and is relatively self-explanatory. The programs all assume that dBASE.COM and all the .CMD files are on drive A and the data are on B (all the program calls are of this form: "DO A:.....”). This procedure may present a problem for hard drive users, one which can be resolved by changing the source code or designating an "A" drive and issuing the "SET DEFA TO A" command in dBASE with both the program and .DBF files on that drive.

Border Star 85 Data Entry Program (Ver 3.0): Program Documentation

Phase 1 of the Border Star 85 project relied heavily on the use of rapid computerization and reporting of TRU data collected in the field. Ashton Tate's dBASE II (Ver. 2.43* copyright 1984) data base software was used to create a two-part system of program packages for the purposes of 1) input, management, and reporting of the raw survey data, and 2) summarizing TRU and site data for a quickly-prepared preliminary compliance report and for choosing Phase II survey units. The use of customized dBASE II programs provided OCA with the potential for rapid turnaround in reporting, standardization in data collection, and quick data summaries without the need for mainframe software capabilities. Most analysis of the Phase I and II data was accomplished on the IBM mainframe at UNM using SAS. dBASE II, however, was more than adequate to serve the needs of the project for simple reporting and summarizing in the field without the need for uploading nearly 10mb of survey data to the mainframe (a process which took over a month).

The dBASE II source code for the programs used follows this discussion. Each program contains a descriptive header which documents the function and role of the program in the input/reporting system. This software system underwent several revisions during the fieldwork and provides—to some extent—a record of the results of the programmer's "learning curve" with dBASE II.

The Border Star 85 data base entry and management program package, consists of a series of linked dBASE II command files (type = *.CMD), stored permanently on the Border Star 85 dBASE II software diskettes. The master command file—or shell—is INPUT.CMD. All other files are called from this file or from files called by it. All subroutines end by passing the user back to the "Main menu" in INPUT from which the user can then select another function or exit to dBASE.

Many of the functions USE one or more files. For example, Option 5 (SORT) of the main menu USEs all Border Star 85 data files plus two scratch files (TEMP1 & TEMP2). An important aspect of the program is the use of a dBASE memory variable (BATCH), which is referenced as a macro expansion (&BATCH) in all file references (e.g., 'USE TRU&BATCH' USES file TRU13 if BATCH = '13'). In addition, the program assumes that SETUP.CMD (also on the dBASE disk) has been "done." This short file SETs the default drive to B. Finally, when the user issues the "DO INPUT" COMMAND in dBASE, it is assumed that a small file also called INPUT.CMD resides on the data disk in drive B. This file has one line: "DO A:INPUT." Copies of the various command files are attached.

Four data file types are maintained by INPUT (dBASE II file "STRUs" appear with the source code which follows the text):

1) TRU data (TRU1, etc.)
2) Ceramic data (CERM1, etc.)
3) Lithic data (LITH1, etc.)
4) Feature data (FEAT1, etc.)

Each file contains the same TRU coordinate variables (KME, KMN, TRUE, and TRUN) thus allowing TRU, lithic, ceramic, and feature data from the same TRU to be linked. Separate files are maintained for the sake of storage efficiency. The numeric suffixes in the data file name correspond to the BATCH number for a "batch" of the four files from one square kilometer in the Border Star 85 survey area; that is, each square kilometer will have a unique BATCH number and data files from that kilometer will have the BATCH number as their suffix.

Although INPUT represents the core of the data entry package, serving essentially as a subroutine manager, the ADD.CMD file is the most important part in that it is responsible for all primary data input. (The one exception is input of noncultural TRUs representing environmental data monitoring points spaced every 100 m) ADD.CMD has the advantages that the loading of different files (as required) and the redundant entry of TRU coordinate data are transparent to the user as is the summarizing of artifact/feature/collection data in the TRU records during input. As a result, the primary input process is more efficient and less subject to error in the entry of the critical TRU coordinates that link files. The other "functions" available inside INPUT can be performed outside the program at the dBASE command level, however, their presence inside the program allows the user to accomplish common tasks with ease.

INPUT allows the following functions (see INPUT.CMD):

1) ADD TRU data (ADD.CMD). This will be the most commonly used option of the main menu and represents the standard data input mode for cultural TRUs (including TRU/CERM/LITH/FEAT data).
2) EDIT data (EDIT.CMD). Allows editing (BROWSEing) or adding (APPEND) data in any of the four files. (Note: Additions to/deletions from CERM/LITH/FEAT require updates of TRU.)
3) Add or edit environmental TRUs (ENVL>CMD). Allows quick entry (APPEND) of noncultural 100-m grid

TRU data. Also allows search of TRU file for these records and editing (BROWSE). The latter uses interesting features of dBASE, but is a bit awkward.

4) Start a new file BATCH (NEWBTCH.CMD). This is done after the current BATCH has been completed (including editing and reporting). It COPYs the four file STRUctures into four new files with the numeric suffix N + 1 and then increments the current BATCH number by 1. Subsequent file calls from the program will access the new BATCH. The process is slightly more involved when changing disks at the same time.

5) SORT all files in the current batch by TRU coordinates (TRUE, TRUN) (INSORT.CMD). Although this takes quite a while to perform, it should be done prior to using the REPORT option or starting a new file BATCH.

6) REPORT (REPORT.CMD). This option prints a report using TRUDATA.FRM (a dBASE REPORT form on drive A). Cultural TRUs from the TRU file (SORTed) and summary data are printed. Instructions for setting up the printer and (optionally) configuring it (see #7) are issued to assist the user.

7) CONFIGURE the printer (PRINTER.CMD). This program guides the user through printer configuration. Provided the printer is not turned off, this configuration can be used at the dBASE command level (P toggles printed O/P on) to get printed copies of LISTs, etc., and even outside dBASE (e.g., WordStar, WASH "L" commands). Several fonts and two additional options (1/8" spacing and italics are available). The program can be accessed from outside INPUT by "DO A:PRINTER." (See "Report Configuration Options" manual for INPUT.)

8) Add SITE numbers to TRUs formerly entered but not noted as from sites. This option was added to accomodate site boundary definitions made in the field office, which superceded or augmented field decisions.

The data input process consists essentially of four parts·

1) Options 1, 2, and 3 (ADD, EDIT, ENVL) of the main menu are used to enter and edit all the data from a square kilometer. Later additions are possible, but crew chiefs should attempt to ensure that KM packages are *complete* before turning them over to the data processing crew chief (DPCC). The data from one square kilometer of survey constitute a BATCH (again, the four files: TRUn, CERMn, LITHn & FEATn). At regular intervals during this process, data should be backed up to BACKUP disks using the WASH utility.

2) Once complete, the current BATCH (i.e., KM) is SORTed and REPORTed and a final backup is made. Option 4 is then used to create a new BATCH of files for the next KM. A list will be maintained of BATCHes and the associated KM coordinates by DP. In most cases, multiple BATCHes will fit on one disk. Files should be limited to ca. 180K in size and enough space should be left on the disk to accomodate a text version of the largest file (usually one of the TRU files). This may result in some KMs falling into two or more BATCHes (hopefully not often). The new BATCH option assumes (it has to) that the new BATCH will be on the same disk. When BATCH changes coincide with disk changes, the new BATCH should be created on the old disk, WASHed to the *new* (formatted by COPY) disk, and then deleted from the *old* disk. The one-line INPUT.CMD on the data disk should be copied too. The new disk can then be used by INPUT and the new number entered when INPUT issues the BATCH prompt.

3) When complete (i.e., 1/2 full to allow for .TXT copies for mainframe uploading), both diskettes and their backups should be protected by covering their write/protect notches with the little silver labels provided. The original diskette is then transported to Albuquerque and turned over to the laboratory supervisor. This is a *very* sensitive point in the process. Diskettes should be well cared for (i.e., put in a box) during transportation and *only* one copy should be moved. Backups will remain in the field for the duration. Prior to transportation, original diskettes should be stored in a separate trailer from the backups (in the office).

4) At OCA, additional backups will be made, and then the originals will be used in the process of creating text versions of the data files for transmission to the IBM.

The structure of the INPUT package appears in Table A2.1. Command file names are in caps. All command files are assumed to reside on drive A with the exception of the one-line INPUT.CMD on B.

Table A2.1. Border Star 85 Input Program Structure

STARTUP
"DO SETUP" @ log-on sets default drive to B
"DO INPUT" then calls: B:INPUT
which calls: A:INPUT
which calls: Main Menu program (plus miscellaneous ones: DADA, PAUSE, TANK/BOMB, COUNTER)

Main menu #/ primary subroutine	Files "USEd"	Other called routines	Screens (FMT) & forms (FRM) used
1) ADD ——> ADD	all four	ADDCERM, ADDLITH, ADDFEAT, COUNTER, INEDIT	FMTCERM, FMTLITH, FMTFEAT, FMTTRU
2) EDIT ——> EDIT	all four	BROWSER	
3) Env'l ——> ENVL	TRUn	INEDIT	
4) BATCH ——> NEWBTCH	all four	none	
5) SORT ——> INSORT	all four	SORTER	
6) REPORT ——> REPORT	TRUn	PRINTER	TRUDATA, SITES, SQKMS, SITESUM
7) CONFIG ——> PRINTER	none	none	
8) SITES ——> SITES	TRUn	none	

Other Utility Functions

Source code for two other utility programs is included following the INPUT group: "SCATTERS.CMD" and "DUPLTRU.CMD." These two programs were used to fix some coding problems, which developed as a result of what came to be known as the "Tuttle factor" (Tuttle was the name of a seventh—and unknown—crew chief), and to locate and delete duplicate TRU entries in the TRU file. These programs illustrate the value of a computerized system such as the Border Star 85 one, in that they show how errors which proliferate in automated systems can be automatically diagnosed and fixed.

Data Summary Programs for In-field Reporting

The survey data summary program package, which includes RECOUNT.CMD, SUMMARY.CMD, SQKMS.CMD, and SITESUM.CMD, was used to (1) update the summary counts in the TRU files (RECOUNT), (2) "fix" UTMs miscalculated by dBASE during INPUT (RECOUNT.CMD), and (3) update summary files including SQKMS.DBF (summary data for sq kms—SQKMS.CMD), SITES.DBF (summary data for site TRUs—SITESUMS.CMD), and SITESUM.DBF (summary data for sites—SITESUMS.CMD). The RECOUNT.CMD package was run on all TRU data entered with the input package once all editing was complete.

This program group had the general function of doing some TRU data cleanup and generating summary data files for reporting purposes. The latter were transported from data disk to master disk so that summary data from the whole survey could be accumulated. When complete, these summary data (much more compact than the raw survey data) were transmitted to the mainframe for preliminary analyses, which formed the basis for two important tasks: 1) preparing a "quick-turnaround" preliminary report for compliance purposes, and 2) choosing survey units for the second phase of the project.

In the infield reporting package—the source code for which follows that for the INPUT package—RECOUNT.CMD acts as the program shell, calling the SUMMARY.CMD, SQKMS.CMD, and SITESUM.CMD programs in order. The processing details are described in the header comments of the RECOUNT program.

Appendix 3

PHASE I SITE DATA FROM THE BORDER STAR 85 SURVEY

William H. Doleman and Peter N. Eschman

The Border Star 85 Phase I Survey documentation consists of Tabie A3.1 from the Border Star 85 report. This table can be found in the microfiche packet.

Table A3.1 provides a summary of data recovered by the Phase I Border Star Survey. This appendix is organized by square kilometer, with the sites sorted by White Sands Missile Range (WSMR) four digit site number within each sqare kilometer. The following variables are shown on the Appendix listing, and discussed in the order in which they appear in the listing. The reader is encouraged to use the WSMR site number for reference to any text discussion of Phase I site data. In some cases, subsequent projects have resulted in more than one Phase I site being subsumed by a single LA number. Table A3.1 provides Phase I data for all sites, as defined during the Phase I survey.

KME	Kilometer Easting, southwest corner of the 1 sq km unit which contains the site center
KMN	Kilometer Northing, southwest corner of the 1 sq km unit which contains the site center
SITE NO.	Four digit WSMR, Border Star 85 Phase I field site number (using White Sands Missile Range site numbering sequence)
LA NO	Laboratory of Anthropology (LA) site number
UTM EAST	UTM Easting, site center
UTM NORTH	UTM Northing, site center
LAND OWNER	Land Ownership

Code	Frequency
WSMR = White Sands Missile Range	1550
BLM = Bureau of Land Management	253
W B = Site is on both WSMR & BLM	5

TOWNSHIP	Township number
RANGE	Range number
SECTION	Section number
ELEVATION	Elevation in ft.
CERAMIC PERIODS	Ceramic Periods represented including:

Code	Frequency
Aceramic	1164
Late Mesilla	209
El Paso	86
Late Mesilla/El Paso	9
Ceramic unknown	340

LITHIC PERIODS	Lithic Periods represented including:

Code	Frequency
No lithics	154
Paleo	7
Archaic	113
Post-Archaic	6
Paleo/Archaic	3
Archaic/post-Archaic	2
Paleo/post-Archaic	1
Lithic unknown	1522

EST AREA SQ M	Estimated site area, in square meters, calculated from the formula: Area = $\pi((33.333 \div 2)\sqrt{\#\ TRUs})^2$
NO. TRUs	Number of transect recording units (TRU) in site
FIRE FEAT	Number of fire feature observations
TRU CERAMICS	Total TRU ceramics
EST CERM COUNT	Estimated ceramics for total site area
TRU LITHICS	Total TRU lithics
EST LITH COUNT	Estimated lithics, flaked & ground, for total site area
DEBITAGE	Number of TRU pieces of debitage
CORES	Number of TRU cores
INFORMAL	Number of TRU informal tools
FORMAL	Number of TRU formal tools
POUNDING	Number of TRU pounding tools
GROUNDSTONE	Number of TRU groundstone
OTHER	Number of TRU other items
FEATURE TYPES AND COUNTS	Feature counts, types 1 to 17 counts 1 through 9 = 1 .. 9 10 through 35 = A .. Z greater than 35 = Z

Column Number
1 = Ceramic scatter
2 = Lithic scatter
3 = Groundstone
4 = Bone
5 = Fire-cracked rock concentration
6 = Fire-cracked rock scatter
7 = Burned caliche concentration
8 = Burned caliche scatter
9 = Fire-cracked rock/burned caliche concentration
10 = Fire-cracked rock/burned caliche scatter
11 = Hearth
12 = Charcoal/ash
13 = Pithouse
14 = Surface architecture
15 = Bedrock mortar
16 = Historic
17 = Other feature

COLLECT STRING	Collected item counts counts 1 through 9 = 1 .. 9 10 through 35 = A .. Z greater than 35 = Z

Column Number
1 = Ceramics
2 = Tools
3 = Obsidian
4 = Points

DOMINANT VEGETATION	Dominant vegetation, including the following individual vegetation types: grasses, mesquite, creosote bush, sagebrush, saltbush, snakeweed, tarbush, other/yucca, none coded
LANDFORM	Landform, including the following values:

Code	Frequency
Low coppice	1032
High coppice	557
Sheet sands	55
Active dune	3
Playa	11
Arroyo	24
Alluvial fan	84
Ridge	12
Low rise	4
Terrace	5
Foothill slope	13
Talus base	1
Talus slope	1
Floodplain/valley	6

LAND SURFACE CHARACTERISTICS	Land Surface string, showing presence = 1 or absence = 0 of the following characteristics:

Column Number
1 = Coppice dunes
2 = Exposed caliche
3 = Playa
4 = Grassland area
5 = Human alteration
6 = Red paleosol
7 = Vegetated arroyo
8 = Active arroyo
9 = Desert pavement
10 = Alluvial fan
11 = Sheetwash

OHER PROJECTS	Other project involvement, coded into a 9 character long string, with the following codes used:

Code	Frequency	Meaning
	1554	Only info is from Border Star 85 Phase I survey
ohr	8	OHara/Rugge road monitoring
ohr,p2o	1	OHara/Rugge road monitoring and in Phase II work
oldla	4	Is pre-existing LA number site
p2o	7	In Phase II work
p2o,s87	1	In Phase II work and in GB-FELTIE 87 survey
p2os87sub	1	In Phase II work, subsumed into GB-FELTIE 87 survey
s87	172	GB-FELTIE 87 survey
s87,mit	1	GB-FELTIE 87 survey and mitigated
s87,swa	5	GB-FELTIE 87 survey and footprint survey
s87,tes	7	GB-FELTIE 87 survey and tested
s87sub	46	Sites subsumed into GB-FELTIE 87 survey site
s87swates	1	GB-FELTIE 87 survey & testing & footprint survey

Note: the phrase "subsumed into GB-FELTIE 87 Survey" means that several Border Star 85 survey sites were later grouped into a single GB-FELTIE 87 survey site. In these cases the lowest LA number corresponding to a Border Star 85 Phase I site number will be used.

Documentation for Monitoring of road construction/improvement prior to the Border Star 85 manuvers consists of copies of the site narratives for these sites.

Documentation for Phase II work consists of copies of the appropriate chapters from the Border Star 85 survey report.

Appendix 4

NOTES ON THE GEOLOGY AND MINERAL RESOURCES OF THE JARILLA MOUNTAINS AREA, OTERO COUNTY, NEW MEXICO

A. Helene Warren

The Rocks of the Jarilla Mountains

Because of the proximity of the Organ and San Andres mountains to the west and the Sacramento Mountains to the east, the sedimentary, igneous, and metamorphic rocks of the project area (Table A4.1) will be briefly discussed on a regional as well as a local basis.

The Sedimentary Rocks

Numerous geologic studies have been made of the Jarilla Mountains and nearby mountain ranges, including the Organ, the Sacramento, and the San Andres. An early investigation of the White Sands area and the Tularosa Basin was made by H. L. Herrick, a geologist and paleon-

Table A4.1. Rocks and minerals of the Jarilla Mountains and vicinity, Otero County, New Mexico

Code Number	Classification and Description	Geologic Sources
1010	Chert, fossiliferous, undifferentiated	Varied
1011	Chert, light gray to dark gray; sparse concentric fossils; cortex usually cream to yellow brown; colors vary from one locality to another	Upper Permian limestones; widespread distribution in source rock and in gravel deposits
1013	Chert, fossiliferous; may have crinoid stems; cream-colored; white to light gray in the Bear Park Area	Lake Valley Formation limestones. Mississippian; Bear Park; Lake Valley
1015	Chert, fossiliferous; olive black (5Y2/1); with tiny rodlike white fossils; + fine inclusions of hematite	Jarilla Mountains (?)
1018	Chert, fossiliferous; variegated; glossy luster; spicule and pelecypod inclusions; undifferentiated (similar cherts have been identified by some workers as "Edwards chert"; no identifications of the fossils have been made of the current artifact materials - AHW)	As above (?)
1019	Chert, fossiliferous, variegated; glossy luster, undifferentiated	As above (?)
1020	Chert, with scattered quartz grains, undifferentiated	Unknown
1022	May be cream-colored; no known source	Unknown
1030	Chert, black, undifferentiated	As above (?)
1031	Chert, black, waxy luster; transluscent on thin edges	As above (?)
1032	Chert, mottled gray to black; tan to brown; banded; usually with scattered, minute hematite inclusions; also with fusilids, sponge spicules (flakes at Water Tank site)	Jarilla Mountains, also Bear Peak, Sacramento Mountains (?)
1036	Chert, light to dark gray; banded; may have concentric bands; dull to glossy luster; may be altered to hornfels	Jarilla Mountains, Bear Peak/San Andres Mountains, Sacramento Mountains
1043	Chert, gray to reddish purple; dull to glossy luster	Southeastern NM, as above
1044	Chert, moderate green, undifferentiated	Undetermined
1047	Chert, olive-green with chalcedonic stringers; dull to glossy luster	As above

Table A4.1. (continued)

Code Number	Classification and Description	Geologic Sources
1050	Chert, white; clear, glossy transluscent (1052)	As above
1054	Chert, chalcedony; clear to white ± black mossy inclusions; occasionally pink	As above
1060	Chert, dark red, undifferentiated	As above
1062	Chert, dark red to purple red; may grade to quartzitic siltstone, sandstone; also to light red, rarely yellow shades	Abo Formation, Permian, and gravels Bear Peak, etc.
1064	Chert, dark red; with clear chalcedony veins	As above
1070	Chert, yellow brown, undifferentiated	Undetermined
1072	Chert, yellow-brown, grades to red with mossy black inclusions	Upper Permian beds
1073	Chert, yellow-brown, with olive brown chalcedony inclusions	As above
1074	Chert, chalcedonic, light brown (10YR6/2) to (10YR5/4), moderate yellow-brown, chalcedonic inclusions; minute hematite inclusions	Jarilla Hills, Upper Permian beds
1075	Chert, dark brown, undifferentiated	???
1079	Chert, yellow to red, ocherous; glossy to dull luster	Yeso Formation (?), San Andres Mountains
1090	Chert, Pedernal; white with black, red, yellow inclusions	Cerro Pedernal; Santa Fe Formation
1091	Chert, Pedernal; as above, chalcedonic	As above
1098	Chert, Pedernal; similar to above 1090 and 1091	As above (?)
1112	Silicified wood, brown to yellow brown; glossy to waxy; with fine hematite inclusions Schmidt and Craddock (1964:14-15)	In Permian marine limestones, northeast Jarilla Mountains
1150	Silicified wood, yellow brown jasper, undifferentiated	Undetermined
1210	Chalcedony, mossy inclusions, undifferentiated	As above
1220	Chalcedony, clear, colorless with scattered yellow inclusions; (moss jasper)	As above
1221	Chalcedony, clear, colorless with abundant yellow inclusions	As above
1231	Chalcedony, abundant red mossy inclusions, undifferentiated	As above
1232	Chalcedony, clear, with scattered yellow and red inclusions	As above
1233	Chalcedony, with abundant yellow and red mossy inclusions	As above
1310	Chalcedony, light yellow	As above
1423	Chert, jasperoid; banded, red, gray, or buff; locally called "Candy Rock" or "Wonder Stone", in Lake Valley	Lake Valley, Socorro, Jarilla mining districts
1425	Chert, red, gray, mottled; undifferentiated	Undetermined
1500	Porcellanite, undifferentiated	????
1505	Porcellanite, cream-colored. Cueva Tuff (?), conchoidal fracture; (2.5Y8/4) (Ruhe 1967) (rhyolite)	Organ Mountains, Dona Ana County
1506	Porcellanite, light to medium gray; with glass shards; cherty; Soledad rhyolite? (Ruhe 1967)	As above

Table A4.1. (continued)

Code Number	Classification and Description	Geologic Sources
1530	Jasperoid, undifferentiated	Varied
1531	Jasperoid, black with limonite inclusions; black crystal quartz druses (Artifact 009-39); also metallic gray (dusky yellowish brown, 10YR2/2) with glossy luster; stringers and veinlets of yellow jasper (light brown 5YR5/6)	Jarilla Mountains, Otero County at iron mines (Iron Duke)
1532	Jasperoid, light gray (N7); dull luster, coarsely crystalline; minute pyrite and chalcopyrite crystals; ± white quartz	As above
1534	Jasperoid, light brown (5YR6/4 to 5/6) to moderate brown (5YR4/4); glossy to dull luster; conchoidal fracture; clear chalcedony stringers; abundant fine-grained quartz crystal druses; clear calcite inclusions; may have dusky red (5R3/4) bands and swirls (artifact 208-11)	As above
1535	Jasperoid, medium to dark red; ± clear chalcedony veinlets	As above
1600	Chert, light gray, undifferentiated	Jarilla Mountains, in Pennsylvanian and Permian limestones
1616	Chert, dark gray, undifferentiated	As above
1620	Chert, tan to light yellow, undifferentiated	Undetermined
1630	Chert, cream colored, undifferentiated	Undetermined
1650	Chert, olive green to olive gray, undifferentiated	As above
1660	Chert, light tan or buff, undifferentiated	Undetermined
2010	Sandstone, fine-grained, indurated, undifferentiated	Undetermined
2201	Sandstone, quartzitic, coarse grained, varicolored	Upper Morrison Formation
2204	Sandstone, siltstone; dark red; grades to red flagstone (code 2275)	Permian beds in Bear Peak area; San Andres and Sacramento mountains
2208	Sandstone, quartzitic; fine-grained; light brown (5YR5/6) weathered cortex, light orange-brown (carboniferous?)	Undetermined
2700	Limestone, undifferentiated	Pennsylvanian and Permian limestones (?)
2710	Limestone, undifferentiated, fossiliferous	As above
2750	Travertine, undifferentiated; white (Artifacts 154-01; 179-10)	Undetermined; possibly from spring deposits, northern Tularosa Valley
3010	Felsite, aphanite (rhyolite?), undifferentiated	Undetermined
3015	Felsophyre, aphanitic groundmass and phenocrysts	Undetermined
3020	Felsophyre, phaneric, felsic	Undetermined
3025	Felsophyre, fine-grained aplite, undifferentiated	Undetermined
3030	Felsophyre, intermediate, undifferentiated	As above
3050	Basalt, aphanitic; gray conchoidal fracture; "trap"	Basalt flows, near Carrizzo, NM (?)
3200	Monzonite, light gray; may have hornblende crystals	Jarilla Mountains
3400	Basalt, iddingsite inclusions; brownish gray (5YR4/1) (Artifact #123-13; grooved stone)	Undetermined; possibly Carrizzo basalt flows
3430	Basalt scoria, red-gray, undifferentiated	Basalt scoria cinder cones north end of Jarilla Mountains
3452	Basalt, olivine, undifferentiated	Undetermined

Table A4.1. (continued)

Code Number	Classification and Description	Geologic Sources
3520	Obsidian, brown, Jemez	Santa Fe gravel, to west along the Rio Grande; Jemez Mountain source
3521	Obsidian, red and brown colors	As above
3523	Obsidian, near opaque	As above
3731	Vitrophyre, rhyolitic, welded, glassy, undifferentiated	As above; possibly Organ Mountains
3745	Vitrophyre, intermediate, hornblende crystals	Undetermined; possible Chico Hills
3746	Vitrophyre, black plus feldspar, olivine crystals	Undetermined
3810	Rhyolite, welded; pebble with blue and white chatoyant phenocrysts of sanidine; matrix light orange (Artifact #144-01)	As above
4000	Quartzite; Artifact #149-02; large ground stone; fine-grained, indurated (hematite stains) with equant subangular grains with sparse biotite	As above
4350	Hornfels, dark gray; fine-grained pelitic	Jarilla Mountains, Otero County
4354	Hornfels, red, yellow, gray, altered mudstone	As above
4400	Marble, white and black veinlets	As above
4420	Tactite; complex metamorphic rocks; may be dark olive or gray; high specific gravity	????
4510	Hornblende schist; elongated fragment; large; "ringing" or "Kiva" stone	From east slopes of San Andres Mountains Precambrian outcrops (?)
4550	Schist, muscovite (Artifact #064-06); pestle; unidentified sparse dark brown mineral inclusions	Possibly Precambrian rocks of Bear Peak or San Andres Mountains
5005	Rock-crystal (SiO2), clear colorless transparent crystals of quartz; used to produce projectile points; conchoidal fracture	Oro Grande and Tularosa districts, Otero County
5010	Rock quartz, crystalline, undifferentiated	Ubiquitous
5011	Rock quartz, crystalline, milky	???
5020	Quartz crystals, frequently as druses in small vugs; colors varied	Jarilla Mountains, Orogrande district, Otero County
5030	Feldspar crystals; large, to 2 inches, weathering out of orthoclase adamellite	As above
5041	Gypsum, selenite; also rock gypsum	Tularosa Basin, White Sands area
5050	Calcite, Iceland spar, clear or chatoyant crystals	Jarilla Mountains, associated with iron mines
5100	Limonite and malachite, massive with andradite (?) crystals	As above
5210	Hematite (specularite); often as boxwork, yellow and red powdery to near black	Jarilla Mountains, associated with iron mines
5300	Turquoise, medium blue and green; in altered monzonite	As above
5310	Azurite and malachite; associated with crysocolla and tenorite	As above
5341	Andradite (garnet); crystals and massive; yellow-brown in color usually	As above
5511	Pyrite, crystals; abundant in iron mines; also jarosite; tenorite, wulfanite in association	As above

tologist. Herrick (1900) noted that the stratified series in the San Andres Mountains, ranging in age from the Precambrian to the Permian and Triassic, represented a longer time period than that apparent in the Sandia and Manzano mountains. He also recognized that the true origin of the saline and gypsum beds was to be sought in the "red series," now termed the Abo and Yeso formations of Permian age.

In the first decade of this century, L. C. Graton (1910) visited the Jarilla Mountains and mining district, describing the limestone as carboniferous strata of uncertain age that had been domed up by an irregular fine-grained monzonite intrusive. Meinzer and Hare (1915) summarized the rocks of the Tularosa Basin from the Precambrian to present.

Fossiliferous limestones of Pennsylvanian and Permian age outcrop in the Jarilla Mountains. Schmidt and Craddock (1964) measured more than 731 m (2400 ft) of fossiliferous and Permian limestones. The Pennsylvanian limestones were correlated with the Bug Scuffle limestone member of the Gobbler Formation; the Permian rocks are predominantly cherty limestones with limestone pebble conglomerate, brown siltstone, and laminated shales in the lower beds. The Permian limestones have been assigned to the Laborecita and Hueco formations of the Upper Permian. The basal beds of the Permian have been subjected to contact metamorphism, resulting in the formation of hornfels, marble, quartzite, jasperoids, and a variety of minerals near the contacts with igneous intrusives.

The Pennsylvanian limestones range from light to dark gray on fresh surfaces to gray, tan, or brown on weathered surfaces (Schmidt and Craddock 1964). The chert occurs in nodules, in bedding planes, or in concentrically banded nodules. Schmidt and Craddock (1964:6–7) report that the chert "has sharp contacts with surrounding limestones but cuts across structures, beds, and fossils in the limestone." Fossils are abundant but fragmented and include fusulinids, bryozoans, brachiopods, and corals. The latter may occur in silicified masses up to 20 cm.

The limestones of the Permian beds are described as gray, cherty, and may have shale, sandstone, and conglomerate beds. Alteration to marble, hornfels, and quartzite may occur. Fusulinids, corals, brachiopods, gastropods, and bryozoa are representative Permian forms. Silicified wood has been found in the early Permian rocks in several localities.

Sedimentary rocks in the Bear Park area of the San Andres Mountains range in age from Precambrian to the Quaternary. Cherts occur in numerous Paleozoic units and are particularly prominent in the Lake Valley Formation of Mississipian age. Colors range from white to black (Bachman and Myers 1969). A similar sequence is reported in the Sierra Blanca on the west-facing slopes, northwest of the Jarilla Mountains.

The Igneous and Metamorphic Rocks

The intrusive rocks of the Jarilla Mountains are mainly of intermediate composition and include diorite, granodiorite, and monzonite. Schmidt and Craddock (1964) report a minimum of three periods of intrusive activity resulting in contact metamorphism of adjacent sedimentary rocks. The igneous rocks include biotite syenodiorite, leucorhyolite, monzonite-adamellite, orthoclase adamellite, and associated dikes. The orthoclase adamellite is characterized by "large, white euhedral crystals of orthoclase" that weather out as separate crystals. The dikes vary in composition and are similar to the igneous rocks into which they intrude. In sedimentary rocks the dikes tend to be more basic than in igneous rocks (Schmidt and Craddock 1964:28). The intrusive rocks of the Organ Mountains are reported to be similar to the Jarilla intrusives. At the northern end of the Jarilla Mountains is an outcrop of red-brown and black scoriaceous and vesicular basalt.

The metamorphic rocks of the Jarilla Mountains are formed by contact metamorphism of sedimentary rocks. Schmidt and Craddock (1964) report that the altered rocks are mainly gray limestone and some calcareous argillaceous siltstone.

Products of the metamorphism include quartz crystals, calcite, specularite, magnetite, pyrite, garnet, diopside, and wollastonite. Rocks formed include hornfels, saccroidal marble, and silicate and crystalline skarns. Of particular interest to the prehistoric Indian and the archeologist, however, was the formation of jasperoid, quartz crystals, and other by-products of contact metamorphism, such as turquoise, azurite, malachite, jarosite, and other supergene minerals.

Volcanic Rocks of the Organ Mountains

Rhyolites of the Organ and Doña Ana mountains and vicinity were apparently an important source of artifact material for prehistoric Indians. Robert V. Ruhe (1967) has provided exacting descriptions of the porcellanites or glassy rhyolites of the Organ and Doña Ana mountains, as well as legal descriptions of the source areas. According to Carmichael (1983:171), the porcellanites were one of the most important artifact materials for flaked tools in the lower Tularosa Basin.

Although the term *porcellanite* has been used to designate silicified tuffs with "flinty, cryptocrystalline textures," the term has also been used for similar sedimentary rock types (Heinrich 1956). The silicified tuffs or porcellanites of the Organ Mountains and vicinity have a glassy matrix with phenocrysts of quartz and feldspar. Glass shards may be present.

Mining and Mineral Resources of the Jarilla Mountains and Vicinity

The Salt Trails

Lieutenant W. F. Smith of the Topographical Engineers may have been the first American to explore the Tularosa Basin and to describe some of its topographic features (Smith 1849). In 1849 Smith traveled northward on a wagon road from El Paso to the spring called Ojo Solidad and from

there 21 mi north to another spring. At that point he followed "a large Indian trail to Canon del Perro" or Dog Canyon. There an Indian trail went directly over the mountain toward the east. On his return from the Sierra Sacramento, Smith crossed the southern point of "an extensive range of white sand hills." This route passed "one mile and a half to the right of Salt Lake."

According to a map of the Tularosa Basin in 1859–1867, the wagon trail to the salt lake followed the eastern slopes of the Organ and San Andres mountains. According to Meinzer and Hare, the Mexicans were attracted to the gold placers of the Jarilla Mountains and the salt found on the alkali flats:

> At the time of the Mexican cession and prior to that time, a wagon road led from El Paso over the desert east of the Franklin, Organ, and San Andres Mountains, to the alkali flats, and a northward continuation of this road is said to have extended to Manzano, in Estancia Valley. . . . The heavy wooden wheels of the oxcarts and the irons with which the oxen were shod are still occasionally seen along this old Mexican salt trail. According to one report the salt was derived from Malpais Spring or Salt Creek, a few men being sent in advance of the main expedition to lead the water over an alkali flat, where it evaporated and deposited its content of salt (1915).

Turquoise Mining in the Jarilla Mountains, Otero County

Indian mining of turquoise in New Mexico was reported as early as 1629 by Fray Geronimo de Zarate-Salmeron in his *Relaciones* (Zarate-Salmeron 1966). The use of turquoise for ornamental and religious purposes had been reported by sixteenth century chroniclers (Hammond and Rey 1940).

In 1858, William P. Blake identified the blue stone mined by the Pueblos at Cerrillos, New Mexico, as turquoise. Since then, numerous other reports of prehistoric turquoise workings have been published in the Southwest. For example, W. E. Hidden reported turquoise "of fine color and quality" in the Jarilla Mountains. He attributed the discovery to the presence of old workings:

> The ancient pottery and stone implements which the writer caused to be unearthed there proved the true character of the work and that the places had been abandoned for several hundred years (1893).

Hidden described the turquoise from the Jarilla mines as occurring in semiglobular or reniform masses up to 2.5 cm (1 in) thick. He reported that 50 kg of marketable turquoise was shipped during the first six months of mining operations in 1879. He also observed that

> the Mexicans believe that both the "old Pueblos" and Aztecs worked these mines and it is true today that the Pueblos value turquoise—which they term "shoo-ar-me"—even more than the Navajoes. The Apaches call it "steh" and care little for it (1893).

The turquoise from the Jarilla Mountains tends to be blue, though green may occur as well (Kunz 1894).

In 1914 Douglas B. Sterrett (1914) reported turquoise claims in the Jarilla mining district "about 2 and 4 miles, respectively, northwest of Oro Grande." One group of claims was about one-third of a mile west of Brice, a post office on the El Paso and Southwestern Railroad spur, and another group was 1.5–2 mi north of Brice. The turquoise deposits are located in east-facing basins.

At least two major groups of claims were reported to have been worked in the late nineteenth century, but only one patented turquoise claim is mentioned, the Tiffany mine under the Alabama claims. The Tiffany mine had been worked by David King in the 1890s.

The De Meules mine was worked between 1896 and 1898. The mine was shut down when De Meules, the owner, was murdered by Jose Flores as a result of a quarrel over payment for Flores' services as a witness at Las Cruces. The De Meules property was later leased to Cy Ryan and Tom Kelly, yielding a large quantity of good turquoise.

Sterrett (1914:702) noted that remnants of prehistoric workings could still be seen in most of the mines but that modern excavations had obliterated most of the evidence.

Field reconnaissance during July, 1985, at several of the turquoise mines failed to yield evidence of prehistoric workings except in the group of mines in Section 10, T22S, R8E. Stone tools included disk-shaped and oval monzonite hammers and unifacially worked jasperoid flakes. No ceramics were recovered. Differential weathering of the tailings does indicate more than one period of turquoise mining at most of the turquoise pits. At least four turquoise artifacts were found during the Border Star 85 survey.

Pigments and Other Minerals

Forty different minerals have been listed for the Orogrande district in the Jarilla Mountains. Many of these were undoubtedly used prehistorically for ornaments, pigments, and artifacts. Some were apparently gathered as fetishes or curiosities, since clusters of small crystals were noted at archeological sites in sand dunes.

Rock crystals or quartz crystals were utilized to make small clear projectile points. Minute quartz dunes are characteristic of the jasperoids that were frequently used to produce flaked tools.

One pendant was carved from a fragment of travertine (CaCo3), a common form of calcite found in spring deposits, fractures in subsurface rocks, and soil horizons. A travertine bead was also recovered.

One small egg-shaped ground stone with a groove around the middle was carved from a fragment of malachite and azurite in a dark brown limonite (?) matrix.

Jasperoids of the Jarilla Mountains

Among the more useful and plentiful prehistoric lithic resources of the Jarilla Mountains are jasperoids, silicified rocks that were formed during periods of hydrothermal activity that resulted in the mineralization and formation of ore deposits.

Jasperoid has been defined as a rock consisting essentially of cryptocrystalline, chalcedonic, or pheonocrystalline sil-

ica, which has formed by the replacement of some other material, ordinarily calcite or dolomite" (Spurr 1898). The colors of jasperoid range from white to various shades of red, gray, and brown to black. Drusy networks and vugs of small crystals, quartz and calcite being common, are characteristic, although other minerals may be present. Jasperoid formed in limestones and dolomites may alter or silicify fossil inclusions.

Lovering (1972:123–130) reported 24 occurrences of jasperoid in New Mexico, all in southwestern New Mexico, including the Bishop Cap and Organ districts, approximately 40 km (25 mi) to the east. The jasperoid at Bishop Cap is described as white and massive, an aphanitic with vugs of drusy quartz; associated minerals include fluorite, calcite, and barite. The jasperoids of the Organ district are also white, fine-grained, and have localized vugs of quartz, aragonite, and dolomite crystals. Also present near the center of the Organ district is a light yellow-gray jasperoid with sparse grains of apatite, hematite, and nontronite (?).

Lovering studied only the jasperoids of southwestern New Mexico; those of the Organ district in the Jarilla Mountains were not included. Jasperoid specimens collected in July, 1985, vary from shades of yellow-brown and brown to light to dark gray banding. The gray shades may reflect the original banding in the local, thin-bedded limestones of Pennsylvanian or Lower Permian age. More distant from the hydrothermal activity associated with the igneous intrusives that domed and altered the limestones, incipient silicification may have resulted in hornfels without distinct color changes.

The jasperoids and hornfels undoubtedly provided prehistoric lithic source materials; evidence for quarry areas was noted mainly in Sections 10 and 15, T22S, R8E.

A bifacially worked flake of brown jasperoid was found at an outcrop of the probable source material on a mine dump at Monte Carlo Gap (SE 1/4 of Section 22, T21S, R8E).

Unaltered gray cherts of the Pennsylvanian and Permian beds were probably used prehistorically. In the absence of visible recrystallization by hydrothermal alteration, these artifacts should be classed as chert.

Metamorphic Rocks

Several artifacts made of metamorphic rocks were collected during the archeological surveys. Some of these may have been formed locally during a period of contact metamorphism, but no definite local sources were identified.

One ground stone artifact was made from fine-grained quartzite. The rock had equant subangular grains with hematite stains, occasional biotite (?) flakes, and hematite stains. The quartzite might possibly be local in the Jarilla Mountains, but this is uncertain.

An elongated fragment of hornblende schist may have come from the eastern slopes of the San Andres Mountains. A muscovite (sericite?) schist pestle with dark brown mineral inclusions may have come from a similar source.

Appendix 5

PHASE II SMALL SITE FEATURES AND ARTIFACTS

Timothy J. Seaman

Appendix 5 presents basic data concerning small site features and artifacts recovered during Phase II survey. The data are presented in a series of tables (Tables A5.1-7) and provide supporting documentation for discussions in Chapters 7 and 8. The tables are provided in the microfiche packet.

Appendix 6

CULTURAL RESOURCES MONITORING PROGRAM

James O'Hara

Between February 28 and March 12, 1985, archeologists from the Office of Contract Archeology, University of New Mexico, were contracted by the U.S. Army to monitor the construction of dirt roads within the area of White Sands Missile Range included in the Border Star 85 exercises. Coordinating the efforts of the archeologists, James O'Hara and Dale Rugge, were Mr. Robert Mitchell (project coordinator for White Sands Missile Range), Mr. Peter Eidenbach (coordinator for archeological fieldwork), and Mr. Harrold Wallace (supervisor of road crews).

On February 28, 1985, the OCA archeologists met with Mr. Eidenbach, who described the project and outlined the work to be conducted. Some of the preexisting 15 ft wide roads that were to be modified needed to be widened to 30 ft while others would only be surface graded (Figure A6.1, end pocket). A number of tank routes were also planned; these routes were not to be formal roads but only trails.

The work effort was outlined as follows:

1) Relocate previously recorded (and identify unrecorded) archeological sites along the roads that were to be widened. The archeologists were to flag these routes. Construction occurring near those archeological sites in danger of destruction should be monitored. Sites adjacent to roads should be marked to prevent destruction.

2) Relocate previously recorded (and identify unrecorded) archeological sites within the roads that were only going to be graded. These roads were to be flagged for easy identification and all sites dealt with in the manner described above.

3) Plan routes that would avoid archeological sites in situations where roads no longer existed.

4) Create and mark routes for tank trails between given points. These trails should avoid archeological sites.

5) Mark archeologically sensitive areas adjacent to roads as off limits to Border Star 85 personnel.

OCA archeologists then met with Mr. Wallace, who discussed his timetable and priorities. Mr. Wallace informed us that some sections of the roads had already been constructed or graded. We therefore added impact assessment to the list of tasks.

The fieldwork was begun on the afternoon of February 28. During the project we frequently met with Mr. Eidenbach and Mr. Wallace to get road work updates.

Field Methods

The routes surveyed during this project can be divided into four categories: double-wide roads (30 ft wide), single-wide roads (15 ft wide), tank trails, and previously constructed roads. Survey methods were slightly different for each category. The following is a discussion of the survey methods employed. Additionally, several miscellaneous tasks were performed and will be described.

Double-Wide Road Construction

The first category of roads surveyed were the double-wide roads that had not been widened and graded as of February 28, 1985. These roads were existing 15 ft wide dirt roads prior to widening into 30 ft wide roads. Since heavy earthmoving equipment was being used, the impact upon archeological sites was potentially substantial. Construction was under way when the archeologists arrived, so these routes were assigned highest priority. Since this area had been included in the Border Star 85 survey conducted by OCA, it was possible to identify immediately sites located on or near the double-wide routes. All sites from the previous survey had been plotted on 1:3000 aerial photographs, and these photos were used during the monitoring program. Using the field copies of 1:3000 air photos, we conducted a pedestrian survey of all segments of the double-wide routes. A corridor approximately 30 ft wide was marked with white flagging tape. All cultural materials were classified according to criteria used during the Border Star 85 survey.

Sites were defined as concentrations of artifacts and/or features such as fire-cracked rock scatters, hearths, or surface structures. Isolated occurrences were defined as single artifacts or a maximum of five widely dispersed artifacts per 10 m sq area.

All new sites and isolated occurrences were plotted on the Border Star 85 field maps and assigned UTM coordinates. It should be emphasized that the UTM coordinates refer to *survey grid coordinates* referencing the aerial imagery and are not necessarily congruent with USGS 1:24,000 UTM coordinates or military 1:25,000 UTM coordinates. An in-field analysis was conducted on cultural materials from previously unrecorded sites and from those areas of recorded sites impacted by construction. Analysis procedures and forms used were identical to those created for the recent Border Star 85 survey.

All observed artifacts and features within areas of construction impact were recorded. For previously undiscovered site locations, additional documentation of artifacts and features lying outside the area of direct impact were recorded by the TRU methods employed during the original Border Star 85 survey.

When a previously recorded site or an unrecorded site was

encountered, efforts were made to reroute the double-wide roads. In all but a few instances, it was possible to avoid impact to archeological sites. When archeological materials were identified adjacent to the road, white and orange flagging tape was placed on the edge of the corridor. The road crews were instructed to avoid areas marked with this type of flagging. If density of artifacts or overall size of a site made it impractical to reroute a portion of a double-wide route, all cultural materials within the corridor were marked with pin flags and recorded. Mr. Wallace and all road crews were informed that pin flags denoted sites and that, when encountered, road construction should be delayed until one of the archeologists arrived to monitor operations. With an archeologist present, heavy equipment operators were permitted to begin improvement of those segments of the roads. If during construction any kind of feature (hearth, fire-cracked rock scatter, or structure) was uncovered, operations were halted until such features could be recorded and excavated, if warranted.

Single-Wide Construction

The second category of roads surveyed were 15 ft wide (designated single-wide) and were located within areas previously surveyed during the Border Star 85 project by OCA. These roads were, for the most part, existing unimproved single-wide trails. The surface of each road was to be graded only; no widening was planned. These routes were marked with white flagging or orange "official route" markers provided by Mr. Eidenbach. As with the double-wide routes, a pedestrian survey was conducted to identify all previously recorded sites and any unrecorded sites that might be encountered. When possible, roads were rerouted around sites. If rerouting was not possible then the sites were recorded and construction was monitored in the fashion previously described for double-wide roads.

On several occasions single-wide routes designated for improvement were not easily discernible due to erosion or eolian deposition. In these instances a 15 ft wide corridor was surveyed and marked with white flagging tape. Such routes did not always match those identified on the maps, so when changes occurred they were noted and Mr. Eidenbach was informed. In these instances all archeological sites were avoided.

Tank Trails

A third type of route that required archeological reconnaissance was the tank trail. Tank trails were cross-country routes connecting assembly areas with dirt ramps that crossed Nike Boulevard. These trails were not to be improved, but a pedestrian survey was conducted in order to enable tanks to avoid all archeological sites. The tank trails were marked with blue "official route" markers. Any previously unrecorded archeological remains were noted and analyzed.

Previously Constructed Roads

The fourth type of road survey conducted included all instances of double- or single-wide roads improved before February 28, 1985 (Figure A6.1). This date marks the beginning of the archeological monitoring project. Most of these roads were already surveyed by OCA as part of the Border Star 85 project, but some segments had not been included in previous archeological surveys. These areas were dealt with last. Aerial photographs were used to identify those previously recorded sites that were impacted by unmonitored road construction. Each site was inspected in order to assess the damage and to see if any cultural materials or features remained. The areas impacted by construction were then marked on the aerial photos. Areas adjacent to the sites were also inspected for any additional archeological materials.

A pedestrian survey was conducted along segments of road that had not been surveyed or monitored previously. In these instances special attention was given to the soil moved to the side of the road during construction and the areas adjacent to the road. Any cultural materials found on or near the roads were plotted on the aerial photos and analyzed. When artifact concentrations were observed directly adjacent to a road it was assumed that some portion of the site had been impacted during construction. Such sites were recorded and analyzed in accordance with the methods previously discussed.

Miscellaneous Tasks

Finally, several miscellaneous tasks were performed. In addition to surveying and monitoring road construction, archeologists were asked to mark certain areas as "off limits" to Border Star 85 personnel. These areas included archeologically sensitive zones near roads or within assembly areas and testing facilities. Another task conducted by archeologists was to identify areas for borrow pits adjacent to the double-wide routes.Borrow pit areas were chosen by Mr. Wallace, with the assistance of the field archeologists, to enable avoidance of all cultural materials.

Survey Results

Approximately 150 linear km of road corridor were surveyed between February 28 and March 13, 1985. During this survey 15 new archeological sites and 43 isolated occurrences were identified and recorded. The majority of the previously unrecorded sites were small and had been missed during the previous OCA survey. Since isolated occurrences had not been plotted on the field photos during the Border Star 85 survey, a number of the items identified on the road survey may already have been recorded. Any duplication was considered justified since information from IOs would be lost during construction. WSMR and LA numbers have been assigned to the 15 "new" sites. The reader should note that these new sites are *not*, however, documented in Table A3.1. That Table presents only data for sites documented for Phase I survey.

While in most instances roads were rerouted around archeological sites, six sites were eventually impacted during construction. All but one of these sites (Site 11) were previously recorded OCA sites, and all were monitored prior to road improvement. It should also be noted that these sites had already been impacted by initial construction of the existing roads. In most cases the improvement

of these roads did not significantly add to the damage already done.

Five sites were impacted by unmonitored construction. Three of these sites had been previously recorded by OCA, and two were identified in areas that had not been previously surveyed. The OCA sites were revisited in order to assess the damage due to construction. The other two sites were identified during the pedestrian survey of previously unsurveyed areas.

The following section provides a brief summary of the sites identified and/or monitored during the White Sands monitoring program.

Previously Unrecorded Archeological Sites: Impact Avoided

Field No.: Site 3
WSMR No.: 1551
LA No.: 62551
Location: Aerial photo C-3
UTM 390100E 3590166N

Description: This site is a small dispersed lithic scatter. Most of the lithic materials are small to medium pieces of debitage, either complete flakes or distal flake fragments. Two small, stemmed projectile points were found and collected. A portion of double-wide road was routed around this site in order to avoid impact.

Field No.: Site 4
WSMR No.: 1552
LA No.: 62552
Location: Aerial photo C-3
UTM 389200E 3592366N

Description: Site 4 is a small lithic scatter with associated fire-cracked rock. Approximately 10–15 pieces of debitage (flakes and angular debris) were noted. The road was routed around the site to avoid impact.

Field No.: Site 5
WSMR No.: 1553
LA No.: 62553
Location: Aerial photo D-3
UTM 390500E 3589233N

Description: This site is a ceramic, lithic, and fire-cracked rock scatter. Several flakes, a mano fragment, a piece of indeterminate Mimbres ware, and several unspecific brownware sherds were noted. The road was routed around the site to avoid impact.

Field No.: Site 7
WSMR No.: 1555
LA No.: 62555
Location: Aerial photo D-8
UTM 391500E 3604566N

Description: This site is a small but concentrated lithic scatter. Several secondary and tertiary reduction flakes, a bifacial reduction flake, an irregular core, and a two-hand mano fragment were noted. Site 7 was adjacent to a double-wide road and was marked for avoidance.

Field No.: Site 8
WSMR No.: 1556
LA No.: 62556
Location: Aerial photo D-2
UTM 390900E 3588033N

Description: This site is a small fire-cracked rock scatter with a single associated unifacial tool. The site is adjacent to a double-wide road and was marked for avoidance.

Field No.: Site 9
WSMR No.: 1557
LA No.: 62557
Location: Aerial photo C-5
UTM 389833E 3595266N

Description: Site 9 is a small fire-cracked rock concentration. No other artifacts were found in association. A segment of double-wide road was routed around the site.

Field No.: Site 10
WSMR No.: 1558
LA No.: 62558
Location: Aerial photo C-5
UTM 389833E 3595166N

Description: This site is a concentration of fire-cracked rock and several pieces of unidentifiable ground stone. The road was routed around the site.

Field No.: Site 12
WSMR No.: 1560
LA No.: 62560
Location: Aerial photo C-2
UTM 388966E 3587266N

Description: This site is a small fire-cracked rock scatter with two associated lithics (a flake and an irregular core). The road was rerouted in order to avoid the site.

Field No.: Site 13
WSMR No.: 1561
LA No.: 62561
Location: Aerial photo C-2
UTM 388533E 3586533N

Description: This site is a dispersed lithic scatter found in an existing road. Secondary and tertiary flakes and one unifacial tool were recorded. All artifacts were found within the road. Since the road was not going to be expanded and since the site was heavily disturbed it was concluded that no further work was warranted.

Field No.: Site 14
WSMR No.: 1562
LA No.: 62562
Location: Aerial photo B-5
UTM 387833E 3595833N

Description: This site is a large scatter of ceramics, lithics, and fire-cracked rock found in a blowout. Artifacts recorded include unspecific brownware, other brownware, secondary and tertiary flakes, retouched flakes, angular debris, and ground stone. The road was routed around this site in order to avoid potential impact.

Field No.: 15
WSMR No.: 1563
LA No.: 62563
Location: Aerial photo A-3
UTM 383966E 3590466N

Description: This site is a small ceramic, lithic, and fire-cracked rock scatter found in a blowout. The ceramics are all unspecific brownware sherds. The lithics include a retouched flake and ground stone fragments. The road was rerouted to avoid the site.

Field No.: Site 16
WSMR No.: 1564
LA No.: 62564
Location: Aerial photo C-6
UTM 389300E 3598733N

Description: Site 16 is a small dispersed lithic scatter. The road was rerouted to avoid this site.

Field No.: Site 17
WSMR No.: 1565
LA No.: 62565
Location: Aerial photo A-3
UTM 384166E 3590333N

Description: Site 17 is a small dispersed lithic scatter with some associated fire-cracked rock located in a blowout. Artifacts include secondary and tertiary flakes, angular debris, and unidentifiable ground stone. A section of tank trail was routed around the site.

LA No.: 62121 (WSMR 1121)
Location: Aerial photo D-2
UTM 391058E 3587085N

Description: This site is a dense lithic scatter and includes secondary reduction flakes, biface reduction flakes, and angular debris. Portions of a double-wide road were routed around this site, which was discovered during Phase I survey.

Archeological Sites Impacted During Monitoring

LA No.: 62769 (WSMR 1769)
Location: Aerial photo D-3
UTM 391300E 3589113N

Description: This site is a large ceramic, lithic, and fire-cracked rock scatter discovered during Phase I survey. Artifacts recorded include secondary and tertiary flakes, angular debris, unidentifiable ground stone, a retouched flake, an irregular core, unspecific brownware, and several sherds of El Paso Polychrome and Chupadero Black-on-white. The total artifact count probably ranged into the hundreds. Several dark stains, which may have been the remains of hearths, were also noted. The site was situated on either side of an arroyo that was originally an old east-west road. The planned improvements called for grading a single-wide route through the arroyo. Since no artifacts were found within the arroyo, it was decided to keep the grader within the bounds of the arroyo. Archeologists were present when the road improvement took place. No additional archeological materials or features were observed during construction.

LA No.: 62060 (WSMR 1060)
Location: Aerial photo C-2
UTM 392466E 3593533N

Description: This site was recorded during the OCA survey of the Border Star 85 area. It is a small ceramic and lithic scatter on and adjacent to a single-wide route. The site was revisited in order to record all the cultural materials that may be impacted by road grading. Several flakes and pieces of unspecified brownwares were recorded. Archeologists were present during road improvement operations. No additional cultural materials were uncovered, but one dark stain did appear after the road was cut down about 7 cm. Upon closer inspection some charcoal and fire-cracked rock was noted, indicating that this feature may have been the remains of a hearth. Not enough of the stain remained, however, to extract a flotation or radiocarbon sample. Its location was plotted on the photo and a plan was drawn to show its dimensions.

LA No.: 62123 (WSMR 1123)
Location: Aerial photo D-2
UTM 391656E 3587556N

Description: This site was initially recorded during the OCA survey of the Border Star 85 area on the White Sands Missile Range. The site is a dense scatter of ceramics, lithics, and fire-cracked rock bisected by an arroyo. A single-wide road was planned that followed the arroyo. When the site was revisited the scatter was found to extend to the sides of the arroyo, but there were no cultural materials within the arroyo. Archeologists monitored the grading operations to ensure that any cultural materials uncovered would be recorded. A stain was exposed on the north bank of the arroyo cut. The stain (51 by 38 cm) was cross-sectioned and designated Feature 1. Most of this feature had been eroded by arroyo cutting. A plan drawing of the feature was made.

LA No.: 62125 (WSMR 1125)
Location: Aerial photo D-2
UTM 391642E 3587026N

Description: This large, dense scatter of ceramics, lithics, and fire-cracked rock was originally located during the OCA Border Star 85 Phase I survey and was subsequently redocumented during the Phase II survey. A portion of the site is within an existing road that was improved. Since the site is extensive and the existing road had already impacted the site, it was decided to monitor grading instead of rerouting the road. When this site was revisited, all cultural materials found on the road, or in areas that might be impacted, were analyzed and recorded on site forms. Numerous primary, secondary, and tertiary flakes; a large trough metate; hammerstones; cores; retouched flakes; and unspecified brownware ceramics were found.

Archeologists were present when grading operations began. Three dark stains were uncovered during the road stripping. Feature 1 was an oval stain measuring 75 by

63 cm. This feature was excavated to a depth of 22 cm. The fill was carefully searched for archeological materials but none were found. Flotation samples and a radiocarbon sample were taken. Feature 2 was a small stain measuring 33 by 40 cm. It was excavated to a depth of 5 cm. A flotation sample was taken, but no cultural materials were found. Feature 3 was a stain measuring 49 by 70 cm and was excavated to a depth of 10 cm. While no artifacts were found, several pieces of fire-cracked rock were noted within the feature. A flotation sample was taken from this feature.

LA No.: 63180 (WSMR 2180)
Location: Aerial photo A-1
UTM 384900E 3586330N

Description: This site is a small lithic scatter located during the OCA Border Star 85 survey. The site is within an existing road that was surface graded. All visible artifacts were recorded during a revisit, and the grading operations were monitored. No additional materials were encountered during construction.

LA No.: 63418 (WSMR 2418)
Location: Aerial photo D-8
UTM 392433E 3599233N

Description: This site is a small lithic scatter found during the OCA Border Star 85 survey. The site was impacted by the construction of a double-wide road. Before construction the site was revisited and all visible artifacts were recorded. The site was monitored during construction but no additional materials were uncovered.

Archeological Sites Impacted Without Being Monitored

LA No.: 62038 (WSMR 1038)
Location: Aerial photo C-6
UTM 392433E 3599233N

Description: This site was originally identified during the OCA Border Star 85 survey. From the aerial photo it was clear that the site was close enough to the road to have been impacted by the new construction. This section of the double-wide had been constructed before archeologists were available to monitor for archeological materials. The site was revisited to assess the damage. Archeologists discovered that the originally identified site was actually part of a much larger one that had not been completely defined on the aerial photo. Instead of cutting into one edge of the site it was discovered that the road actually bisected the site. The road was inspected for any cultural materials or features that might have been uncovered but none were found. It was determined that actual impact was minimal since the older road had only been widened. The site boundaries were redefined and information was collected from the unrecorded portions of the site.

LA No.: 63125 (WSMR 2125)
Location: Aerial Photo B-5
UTM 387759E 3595322N

Description: This site was identified during the OCA Border Star 85 survey as a sparse lithic scatter. It is located on and near an existing road that was widened to a double-wide. The improvement took place before archeologists could be present to monitor the activity. The site was inspected in order to assess the amount of damage from construction. Archeologists did not find any evidence that the site was substantially disturbed. It appears that the site is dispersed and as a result was not seriously impacted.

LA No.: 63815 (WSMR 2815)
Location: Aerial photo C-8
UTM 388433E 3603466N

Description: This site was located during the OCA Border Star 85 survey. It was identified as a sparse lithic scatter. The double-wide road was constructed before archeologists were present to monitor the operations.A large portion of the site area was removed during construction. The archeologists could not find any cultural materials within the road after construction had taken place. Some of the site remains intact, however, it must be considered impacted by road construction.

Field No.: Site 18
WSMR No.: 1566
LA No.: 62566
Location: Aerial photo D-7
UTM 392333E 3600066N

Description: This site is outside the areas surveyed by OCA during the Border Star 85 survey. It is a small lithic and fire-cracked scatter found adjacent to a single-wide road that had been improved prior to the monitoring program. While no cultural materials were found in the road, it is highly probable that a portion of this site was destroyed. Four tertiary flakes and one piece of angular debris were recorded.

Field No.: Site 19
WSMR No.: 1567
LA No.: 62567
Location: Aerial photo D-8
UTM 392333E 3602633N

Description: Site 19 is also within the unsurveyed area. The existing roads were graded but not widened. This site is a small but dense concentration of lithics and fire-cracked rock. Artifacts include bifacial reduction flakes, secondary and tertiary flakes, metate fragments, and a unifacial tool. It is possible that this site is representative of smaller Archaic sites found within the Tularosa Basin. Since the site is adjacent to the improved road it is highly probable that a portion of the site was destroyed during road improvement. It is impossible to assess the actual extent of impact, however.

Appendix 7

BORDER STAR 85 HISTORIC RESOURCES DATA

William H. Doleman

Appendix 7 presents data concerning non-military historic artifacts as a table (Table A7.1) in the microfiche packet.

Appendix 8

EL PASO BROWNWARE RIM DATA

Timothy J. Seaman and Barbara J. Mills

Appendix 8 presents data concerning El Paso Brownware rim sherds collected during Phase I and Phase II surveys (Table A8.1). These data are included in the microfiche packet.

Appendix 9

PETROGRAPHIC DATA FOR BORDER STAR 85, MIMBRES, FORT BLISS, AND FAIRCHILD SITE SHERD SAMPLES

Dale Rugge

Appendix 9 consists of Tables A9.1-A9.8 which present raw data concerning petrographic analysis of Mimbres Black-on-white sherd collections from four project areas in southern New Mexico. The tables can be found in the microfiche packet.

Appendix 10

COLLECTED PROJECTILE POINTS

James O'Hara

PALEOINDIAN TYPES
N=17
(Figure A10.1)

DESCRIPTION

Paleoindian point types recovered during survey included Folsom, Plainview, Midland, Eden and a number of unclassified forms. Due to their fragmentary nature, dimensions and outline shape descriptions are not attempted.

JAY TYPE
N=7
(Figure A10.2)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	5.55	4.42	6.54
Maximum Width (M7)	2.50	2.08	3.26
Notch Width (M5)	2.60	1.84	3.75
Shoulder Width (M4)	0.45	0.22	0.74
Haft Element Length (M3)	2.19	1.64	3.33
Maximum Basal Width (M9)	1.26	1.04	1.78
Basal Width/Height Ratio (M8)	0.32	0.19	0.46
Basal Angle (A1)**	0.29	0.08	0.90
Angle at Shoulder (A4)**	1.25	1.51	2.19

Outline:

Blade: Lanceolate form, long triangular shape with convex edges.
Shoulder: Slight but distinguishable shoulders forming an obtuse angle.
Stem: Long parallel stems with straight edges, few instances of contracting stems. Stem represents 1/2 to 1/3 of total length.
Base: Straight to convex, majority are straight.

CULTURAL AFFILIATIONS Early Archaic
Dates between 7500–6800 BP

Identified in northern New Mexico and Four Corners area, distribution extends further south and east. Relatively uncommon in southern New Mexico.

REFERENCES
Irwin-Williams (1973)
O'Hara and Elyea (1985)

BAJADA TYPE
N=5
(Figure A10.3)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	5.15	5.03	5.26
Maximum Width (M7)	2.14	2.00	2.36
Notch Width (M5)	2.54	1.92	2.93
Shoulder Width (M4)	0.55	0.25	1.12
Haft Element Length (M3)	2.03	1.73	2.41
Maximum Basal Width (M9)	1.14	0.84	1.48
Basal Width/Height Ratio (M8)	0.30	0.21	0.35
Basal Angle (A1)**	0.16	–.30	0.62
Angle at Shoulder (A4)**	1.69	0.93	2.41

Outline:

Blade: Lanceolate form, long triangular shape with straight to convex edges.
Shoulder: Slight but distinguishable shoulders forming an obtuse angle.
Stem: Long parallel stems with straight edges. Stem represents 1/2 to 1/3 total length.
Base: Pronounced concave base.

CULTURAL AFFILIATIONS Early Archaic
Dates between 6800–5200 BP

Identified in northern New Mexico and Four Corners area, distribution extends further south and east. Relatively uncommon in southern New Mexico.

REFERENCES
Irwin-Williams (1973)
O'Hara and Elyea (1985)

*Measured in cm **Measured from Horizontal

UVALDE TYPE
N=8
(Figures A10.2, A10.3)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.81	3.32	4.63
Maximum Width (M7)	2.36	1.46	2.86
Notch Width (M5)	1.09	0.65	1.37
Shoulder Width (M4)	0.44	0.28	0.58
Haft Element Length (M3)	0.99	0.63	1.37
Maximum Basal Width (M9)	1.56	0.62	2.20
Basal Width/Height Ratio (M8)	0.84	0.42	1.26
Basal Angle (A1)**	-.17	-.57	0.34
Angle at Shoulder (A4)**	0.16	-.32	0.86

Outline:

Blade: Triangular to leaf shaped blade, straight to convex edges.
Shoulder: Prominent shoulders rounded to barbed, forms an acute angle.
Stem: Expands strongly, sometimes terminates at a point as wide as shoulders.
Base: Deep U shaped concavity, basal stems flare outwards.

CULTURAL AFFILIATIONS Early Archaic
Dates range between 6000 to 4500 years BP

Distributed primarily from central Texas toward lower Guadalupe River Valley and Pecos-Rio Grande confluence.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Roney (1985)
Turner and Hester (1985)

TRAVIS TYPE
N=1
(Figure A10.3)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)			5.10
Maximum Width (M7)			1.76
Notch Width (M5)			1.87
Shoulder Width (M4)			1.05
Haft Element Length (M3)			0.83
Maximum Basal Width (M9)			0.80
Basal Width/Height Ratio (M8)			0.50
Basal Angle (A1)**			-.29
Angle at Shoulder (A4)**			1.31

Outline:

Blade: Triangular to leaf shaped edges straight to convex.
Shoulder: Slight and rounded grade into stem.
Stem: Rectangular with parallel edges, may expand or contract.
Base: Usually straight, but will vary by expanding or contracting slightly.

CULTURAL AFFILIATIONS Early Archaic
Dates range between 6500 and 4000 years BP

Distributed from central Texas outward.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Roney (1985)
Turner and Hester (1985)

ANGOSTURA TYPE
N=1
(Figure A10.3)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)			7.73
Maximum Width (M7)			1.62
Notch Width (M5)			3.32
Shoulder Width (M4)			1.31
Haft Element Length (M3)			2.02
Maximum Basal Width (M9)			0.80
Basal Width/Height Ratio (M8)			0.20
Basal Angle (A1)**			0.07
Angle at Shoulder (A4)**			1.51

Outline:

Blade: Lanceolate form with narrow leaf shaped blade with convex edges.
Shoulder: Slight shoulders formed at the point where the stem contracts.
Stem: Contracting stem with straight edges.
Base: Concave to convex.

CULTURAL AFFILIATIONS Early Archaic
Dates between 8000 to 6000 years BP

Distributed throughout Great Plains into western Texas and eastern New Mexico.

REFERENCES
Suhm and Jelks (1962)
Roney (1985)
Turner and Hester (1985)

*Measured in cm **Measured from Horizontal

PANDALE TYPE
N=7
(Figure A10.4)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	4.24	4.03	4.48
Maximum Width (M7)	1.43	1.12	1.86
Notch Width (M5)	1.56	0.99	2.51
Shoulder Width (M4)	0.69	0.24	1.25
Haft Element Length (M3)	0.89	0.41	1.94
Maximum Basal Width (M9)	0.65	0.36	1.26
Basal Width/Height Ratio (M8)	0.51	0.20	0.88
Basal Angle (A1)**	–.03	–.65	0.76
Angle at Shoulder (A4)**	1.55	1.11	2.47

Outline:

Blade: Leaf shaped usually with convex edges, occasionally straight or recurvate.
Shoulder: Poorly developed, point at which stem begins to contract.
Stem: Variable from parallel edged to expanded to contracted.
Base: Very straight, convex, concave.

CULTURAL AFFILIATIONS Early to Middle Archaic
Dates between 4000 to 2800 years BP

Distribution centers in the Pecos-Rio Grande confluence area, less prevalent towards central Texas.

REFERENCES
Suhm and Jelks (1962)
Johnson (1964)
Mallouf (1985)
Turner and Hester (1985)

LERMA TYPE
N=6
(Figure A10.4)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	4.07	3.38	5.32
Maximum Width (M7)	1.58	1.64	1.86
Notch Width (M5)	1.40	0.86	1.99
Shoulder Width (M4)	0.63	0.43	0.93
Haft Element Length (M3)	0.81	0.43	1.05
Maximum Basal Width (M9)	0.72	0.42	1.08
Basal Width/Height Ratio (M8)	0.64	0.24	0.86
Basal Angle (A1)**	0.18	–.59	0.87
Angle at Shoulder (A4)**	1.68	1.23	1.90

Outline:

Blade: Long, double pointed, leaf shaped blade, edges convex.
Shoulder: Shoulders at a point where the stem begins to contract, barely distinguishable.
Stem: Contracts to a point, edges convex.
Base: Acute angle almost pointed, to convex.

CULTURAL AFFILIATIONS Early to Middle Archaic
Dates between 8500–6500 years BP

Distributed through western central Texas to Pecos River, to central coast and southwestern Texas.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Turner and Hester (1985)

MARTINDALE TYPE
N=5
(Figure A10.4)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	2.41	2.25	2.57
Maximum Width (M7)	2.09	1.62	2.30
Notch Width (M5)	1.04	0.68	1.41
Shoulder Width (M4)	0.50	0.44	0.67
Haft Element Length (M3)	0.85	0.50	1.01
Maximum Basal Width (M9)	1.40	1.10	2.00
Basal Width/Height Ratio (M8)	0.95	0.59	0.79
Basal Angle (A1)**	0.11	0.10	0.25
Angle at Shoulder (A4)**	2.24	2.25	3.11

Outline:

Blade: Triangular with straight edges, some examples slightly concaved.
Shoulder: Pronounced shoulder, barbed, acute angle.
Stem: Expands, distal points are as wide as shoulders.
Base: Slight concavity.

CULTURAL AFFILIATIONS Early to Middle Archaic
Dates from 6000 to 100 years BP

Identified in central Texas in the Guadalupe River Region.

REFERENCES
Johnson, et al.(1962)
Turner and Hester (1985)

*Measured in cm **Measured from Horizontal

SAN JOSE TYPE
N=8
(Figure A10.5)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.84	2.75	4.69
Maximum Width (M7)	1.97	1.42	2.84
Notch Width (M5)	1.05	0.80	1.45
Shoulder Width (M4)	0.53	0.12	0.55
Haft Element Length (M3)	0.74	0.39	1.22
Maximum Basal Width (M9)	1.27	0.76	1.94
Basal Width/Height Ratio (M8)	1.01	0.61	1.41
Basal Angle (A1)**	-.13	-.61	0.73
Angle at Shoulder (A4)**	1.21	0.23	2.29

Outline:

Blade: Triangular blade with straight to convex edges—sometimes serrated.
Shoulder: Slight protrusion defined by proximal extent of side notch.
Stem: Expands to points as wide as shoulder.
Base: Pronounced basal concavity, almost bifurcation.

CULTURAL AFFILIATIONS Middle Archaic
Dates between 500 and 3800 years BP

Identified from Puerco area of New Mexico. Wide distribution across northern New Mexico and the Four Corners areas.

REFERENCES
Irwin-Williams (1973)
O'Hara and Elyea (1985)

CHIRICAHUA TYPE
N=6
(Figure A10.5)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	2.83	2.25	3.41
Maximum Width (M7)	1.58	1.18	1.82
Notch Width (M5)	0.55	0.45	0.67
Shoulder Width (M4)	0.30	0.22	0.40
Haft Element Length (M3)	0.35	0.31	0.38
Maximum Basal Width (M9)	1.40	1.26	1.64
Basal Width/Height Ratio (M8)	2.06	1.72	2.35
Basal Angle (A1)**	-.07	-.40	0.35
Angle at Shoulder (A4)**	1.61	0.89	2.37

Outline:

Blade: Triangular, usually convex, some straight.
Shoulder: Slight, well rounded forming an acute angle.
Expanding out from side notches to a point usually wider than shoulders.
Base: Pronounced concavity.

CULTURAL AFFILIATIONS Middle Archaic
Dates range between 7500–3000 years BP

Distributed from eastern Arizona north to Four Corners area and southeastern New Mexico.

REFERENCES
Sayles and Antevs (1941)
Dick (1965)
Sayles (1983)

AUGUSTINE TYPE
N=50
(Figure A10.5)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximun.*
Maximum Length (M6)	3.37	2.98	3.88
Maximum Width (M7)	1.98	1.30	2.52
Notch Width (M5)	1.05	0.79	1.29
Shoulder Width (M4)	0.45	0.34	0.55
Haft Element Length (M3)	0.66	0.42	0.99
Maximum Basal Width (M9)	0.96	0.68	1.30
Basal Width/Height Ratio (M8)	0.95	0.44	1.42
Basal Angle (A1)**	0.07	0.60	0.59
Angle at Shoulder (A4)**	1.82	0.33	2.99

Outline:

Blade: Broad triangular blade, edges straight to convex.
Shoulder: Well defined, straight, usually at right angle to stem. Varies to rounded, obtuse angle.
Stem: Straight to contracting.
Base: Strongly convex.

CULTURAL AFFILIATIONS Middle Archaic
Dates between 6000 BP to 3000 BP

Distributed from eastern Arizona north to the Four Corners area and southwestern New Mexico.

REFERENCES
Dick (1965)
Beckett (1980)

*Measured in cm **Measured from Horizontal

MARCOS TYPE
N=22
(Figure A10.6)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.22	2.23	4.04
Maximum Width (M7)	2.05	1.36	2.62
Notch Width (M5)	0.55	0.34	0.91
Shoulder Width (M4)	0.49	0.16	0.75
Haft Element Length (M3)	0.51	0.22	1.23
Maximum Basal Width (M9)	1.50	1.02	2.40
Basal Width/Height Ratio (M8)	2.50	0.88	3.61
Basal Angle (A1)**	0.10	–.35	0.46
Angle at Shoulder (A4)**	1.02	–.47	3.81

Outline:

Blade: Broad triangular blade with straight, convex or slightly recurved edges.
Shoulder: Deep corner notches usually at a 45 degree angle, barb tips sometimes in line with base.
Stem: Expanding stems project to a point wider than at the shoulders.
Base: Convex base usually not as wide as barbs.

CULTURAL AFFILIATIONS Middle to Late Archaic
Dates from 4000 to 1000 years BP

Distributed in central and southern Texas.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Roney (1985)
Turner and Hester (1985)

SHUMLA TYPE
N=10
(Figure A10.7)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.55	2.35	5.35
Maximum Width (M7)	4.05	1.76	3.04
Notch Width (M5)	0.72	0.64	0.86
Shoulder Width (M4)	0.64	0.50	0.93
Haft Element Length (M3)	0.64	0.39	1.06
Maximum Basal Width (M9)	3.10	0.70	1.80
Basal Width/Height Ratio (M8)	2.25	0.55	2.87
Basal Angle (A1)**	0.03	–.37	0.28
Angle at Shoulder (A4)**	0.78	–.99	4.10

Outline:

Blade: Large triangular blade with straight or convex edges.
Shoulder: Pronounced basal notching with long to sharp barbs extending laterally or into line with the stem base.
Stem: Edges are parallel or slightly contracting.
Base: Convex to straight.

CULTURAL AFFILIATIONS Middle to Late Archaic
Dating to 2800 to 1200 years BP

Frequently identified around the Pecos-Rio Grande confluence along the Rio Grande into the Big Bend and northern Coahuila area.

REFERENCES
Suhm and Jelks (1962)
Sorrow (1968)
Mallouf (1985)
Roney (1985)
Turner and Hester (1985)

CARROLTON TYPE
N=5
(Figures A10.7, A10.8)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.15	2.65	3.47
Maximum Width (M7)	2.08	1.74	2.46
Notch Width (M5)	1.19	1.04	1.32
Shoulder Width (M4)	0.61	0.48	0.74
Haft Element Length (M3)	0.76	0.48	0.96
Maximum Basal Width (M9)	1.28	1.14	1.60
Basal Width/Height Ratio (M8)	0.91	0.64	1.29
Basal Angle (A1)**	0.02	–.22	0.32
Angle at Shoulder (A4)**	1.92	0.61	3.06

Outline:

Blade: Short triangular blade with straight edges.
Shoulder: Prominent squared shoulders usually forming right angle.
Stem: Roughly rectangular with straight edges.
Base: Straight to slightly convex.

CULTURAL AFFILIATIONS Late Archaic
Dates between 4000 to 2000 BP

Distributed central to western Texas.

REFERENCES
Suhm and Jelks (1962)
Turner and Hester (1985)

*Measured in cm **Measured from Horizontal

BULLVERDE TYPE
N=6
(Figure A10.8)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	4.08	3.50	5.80
Maximum Width (M7)	2.47	2.02	2.76
Notch Width (M5)	1.25	0.98	1.45
Shoulder Width (M4)	0.51	0.42	0.62
Haft Element Length (M3)	1.00	0.71	1.26
Maximum Basal Width (M9)	1.49	0.90	2.02
Basal Width/Height Ratio (M8)	0.75	0.49	0.89
Basal Angle (A1)**	0.03	−.13	0.33
Angle at Shoulder (A4)**	1.29	−.31	2.76

Outline:

Blade: Triangular blade with straight to convex edges.
Shoulder: Prominent barb forms an acute angle.
Stem: Rectangular or slightly contracting with straight edges.
Base: Straight or slightly convex.

CULTURAL AFFILIATIONS Early to Middle Archaic
Dates between 5000 to 2600 years BP

Distributed in central to western Texas.

REFERENCES
Suhm and Jelks (1962)
Roney (1985)
Turner and Hester (1985)

PEDERNALES TYPE
N=2
(Figure A10.8)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	—	—	—
Maximum Width (M7)	2.57	2.20	2.94
Notch Width (M5)	1.56	1.26	1.85
Shoulder Width (M4)	0.61	0.55	0.66
Haft Element Length (M3)	1.23	1.09	1.38
Maximum Basal Width (M9)	0.82	0.74	0.90
Basal Width/Height Ratio (M8)	0.44	0.38	0.49
Basal Angle (A1)**	−.67	−.81	−.52
Angle at Shoulder (A4)**	0.41	0.67	0.74

Outline:

Blade: Triangular to leaf shaped edges usually straight or convex.
Shoulders: Shoulders vary from straight right angular to less pronounced acute angles–some barbed.
Stem: Rectangular straight edged with some contracting.
Base: Deep U shaped bifurcated base–distinctive.

CULTURAL AFFILIATIONS Middle to Late Archaic
Dates between 4200 and 1000 years BP

Found mainly in central, coastal, north central and Trans-Pecos Texas.

REFERENCES
Suhm and Jelks (1962)
Johnson (1964)
Roney (1985)
Turner and Hester (1985)

PALMILLAS TYPE
N=14
(Figure A10.18)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.70	2.85	4.92
Maximum Width (M7)	1.94	1.04	2.70
Notch Width (M5)	0.88	0.57	1.24
Shoulder Width (M4)	0.45	0.31	0.80
Haft Element Length (M3)	0.56	0.34	0.76
Maximum Basal Width (M9)	1.35	0.72	2.22
Basal Width/Height Ratio (M8)	1.40	0.81	2.01
Basal Angle (A1)**	0.14	−.65	0.65
Angle at Shoulder (A4)**	1.28	−.26	2.85

Outline:

Blade: Small triangular to leaf shaped, straight to convex edges.
Shoulder: Vary from well barbed to various grades.
Stem: Small bulbous stem, with expanded rounded sides.
Base: Convex some straight.

CULTURAL AFFILIATIONS Late Archaic
Dates between 2000 and 1000 years BP

Distributed primarily in Trans-Pecos Region, extends southward into Mexico.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Roney (1985)
Turner and Hester (1985)

*Measured in cm **Measured from Horizontal

SA.ˣ PEDRO TYPE
N=14
(Figures A10.9, A10.10)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.80	2.96	5.78
Maximum Width (M7)	1.81	1.38	2.58
Notch Width (M5)	0.95	0.49	1.44
Shoulder Width (M4)	0.44	0.26	0.83
Haft Element Length (M3)	0.63	0.27	0.98
Maximum Basal Width (M9)	1.49	0.96	1.74
Basal Width/Height Ratio (M8)	1.54	0.67	2.78
Basal Angle (A1)**	0.09	-.46	0.43
Angle at Shoulder (A4)**	1.09	0.23	2.60

Outline:

Blade: Triangular with straight to convex edges.
Shoulder: Slight protrusion, usually rounded forming an acute angle.
Stem: Short, expanding to a point as wide as the shoulders defined by the extent of the notch.
Base: Majority convex, some straight.

CULTURAL AFFILIATIONS Late Archaic
Dates between 3500 to 2000 years BP

Distributed from eastern Arizona north to the Four Corners area and southeastern New Mexico

REFERENCES
Sayles and Antevs (1941)
Dick (1965)
Sayles (1983)

PAISANO TYPE
N=6
(Figure A10.10)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	2.95	2.05	3.78
Maximum Width (M7)	1.58	1.34	1.84
Notch Width (M5)	0.93	0.66	1.18
Shoulder Width (M4)	0.41	0.19	0.71
Haft Element Length (M3)	0.55	0.33	0.86
Maximum Basal Width (M9)	1.17	0.80	1.40
Basal Width/Height Ratio (M8)	1.17	0.71	1.48
Basal Angle (A1)**	-.19	-.54	0.20
Angle at Shoulder (A4)**	1.45	0.94	1.84

Outline:

Blade: Triangular long blades with convex edges, sometimes serrated.
Shoulder: Slight protrusion just above notch.
Stem: Formed by side notch, flares outward at about 45 degrees. Corners are rounded.
Base: Concave to deeply indented.

CULTURAL AFFILIATIONS Late Archaic
Dates between 1200–800 years BP

Distributed throughout the southern part of Trans-Pecos Texas.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Roney (1985)
Turner and Hester (1985)

DARL TYPE
N=2
(Figure A10.11)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	2.72	2.72	2.72
Maximum Width (M7)	1.69	1.30	2.08
Notch Width (M5)	1.12	0.93	1.31
Shoulder Width (M4)	0.34	0.29	0.38
Haft Element Length (M3)	0.80	0.66	0.95
Maximum Basal Width (M9)	1.53	0.94	2.12
Basal Width/Height Ratio (M8)	0.92	0.71	1.12
Basal Angle (A1)**	-.01	-.10	0.09
Angle at Shoulder (A4)**	1.56	1.29	1.83

Outline:

Blade: Triangular with straight edges.
Shoulders: Slight shoulders ranging in shape from a right angle to slightly obtuse, no barbs.
Stem: Straight to slightly expanding, width toward base is equal to or slightly wider than at the shoulders.
Base: Straight

CULTURAL AFFILIATIONS Late Archaic
Dated between 2000 to 900 years BP

Common in central and north central Texas and westward to the Pecos River.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Roney (1985)
Turner and Hester (1985)

*Measured in cm **Measured from Horizontal

ENSOR TYPE
N=6
(Figure A10.11)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.55	2.89	4.40
Maximum Width (M7)	1.86	1.24	2.72
Notch Width (M5)	0.54	0.41	0.79
Shoulder Width (M4)	0.40	0.27	0.71
Haft Element Length (M3)	0.36	0.27	0.31
Maximum Basal Width (M9)	1.48	1.12	1.84
Basal Width/Height Ratio (M8)	2.30	1.29	3.35
Basal Angle (A1)**	0.02	0.08	0.22
Angle at Shoulder (A4)**	1.66	0.65	3.08

Outline:

Blade: Triangular, variable with respect to width and length, edges are straight or convex and occasionally serrated.
Shoulders: Side notched, shoulders pronounced to form acute angle.
Stem: Broad expanding ending at a point even to barbs.
Base: Typically straight occasionally convex.

CULTURAL AFFILIATIONS Late Archaic
Dates between 2100 to 1000 years BP

Occurs in central Texas and the eastern Trans-Pecos River area southward towards the lower Guadalupe River.

REFERENCES
Suhm and Jelks (1962)
Sorrow (1968)
Mallouf (1985)
Roney (1985)
Turner and Hester (1985)

EDGEWOOD TYPE
N=4
(Figure A10.11)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	2.60	1.96	3.24
Maximum Width (M7)	1.76	1.22	2.34
Notch Width (M5)	0.65	0.54	0.83
Shoulder Width (M4)	0.41	0.36	0.49
Haft Element Length (M3)	0.55	0.43	0.72
Maximum Basal Width (M9)	1.10	0.70	1.50
Basal Width/Height Ratio (M8)	[illegible]	0.81	1.63
Basal Angle (A1)**	[illegible]	-.40	0.22
Angle at Shoulder (A4)**	[illegible]	0.39	3.41

Outline:

Blades: Short triangular blade with straight, usually convex edges.
Shoulders: Prominent barb formed by corner notch, acute angle.
Stem: Expands, terminating at a point almost as wide as shoulders.
Base: Concave.

CULTURAL AFFILIATIONS Late in Archaic Stage to Post Archaic
Dates between 1500 and 1000 BP

Distributed in northeastern Texas toward central and north central Texas as far west as Trans-Pecos area.

REFERENCES
Suhm and Jelks (1962)
Johnson (1964)
Mallouf (1985)
Turner and Hester (1985)

ELLIS TYPE
N=16
(Figure A10.12)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.03	2.30	4.44
Maximum Width (M7)	1.97	1.44	2.64
Notch Width (M5)	0.73	0.54	1.09
Shoulder Width (M4)	0.42	0.24	0.62
Haft Element Length (M3)	0.56	0.33	0.84
Maximum Basal Width (M9)	1.39	1.08	1.96
Basal Width/Height Ratio (M8)	1.35	0.83	1.89
Basal Angle (A1)**	0.11	-.42	0.38
Angle at Shoulder (A4)**	1.09	-.42	3.39

Outline:

Blade: Short triangular blade with straight to convex edges.
Shoulder: Prominent shoulders, often corner notched barbs, forms an acute angle.
Stem: Stem expands toward base, but is not as wide as shoulders, edges are straight to concave with cut out corners.
Base: Straight to convex.

CULTURAL AFFILIATIONS Late Archaic
Dates between 1500 and 1000 BP

Prevalent Archaic form found throughout Texas similar to Edgewood. Identified in the eastern Trans-Pecos.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Turner and Hester (1985)

*Measured in cm **Measured from Horizontal

BS TYPE I
N=21
(Figures A10.13, A10.14)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	4.81	2.95	7.92
Maximum Width (M7)	2.13	1.64	3.00
Notch Width (M5)	0.91	0.56	1.32
Shoulder Width (M4)	0.54	0.29	0.20
Haft Element Length (M3)	0.66	0.45	0.87
Maximum Basal Width (M9)	1.25	0.64	1.88
Basal Width/Height Ratio (M8)	1.04	0.42	2.01
Basal Angle (A1)**	0.07	–.52	0.49
Angle at Shoulder (A4)**	1.74	–.20	3.58

Outline:

Blade: Long slender triangular blade, most examples have straight edges with evidence of serration. Some instances in reworked blades where the edge is concave.
Shoulder: Straight, well pronounced, either straight at a 90° angle to stem or slightly barbed forming an acute angle.
Stem: Parallel to slightly expanding with straight edges, majority narrower than shoulders.
Base: Straight base to slightly convex.

CULTURAL AFFILIATIONS Unknown Probable Late Archaic†

This type appears to be significantly different from other control types identified for the Oshara, Cochise, and Trans-Pecos areas. While similar in form to known types, BS Type I varies enough to represent a distinct type. Probably distributed throughout Tularosa Basin and adjacent areas.

REFERENCES

†Similar points identified in Beckett (1983a)

BS TYPE II
N=9
(Figure A10.14)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	4.09	2.78	6.17
Maximum Width (M7)	1.92	1.62	2.30
Notch Width (M5)	0.74	0.56	0.92
Shoulder Width (M4)	0.49	0.36	0.64
Haft Element Length (M3)	0.57	0.38	0.73
Maximum Basal Width (M9)	0.92	0.50	1.20
Basal Width/Height Ratio (M8)	0.92	0.46	1.82
Basal Angle (A1)**	–.20	–.54	0.28
Angle at Shoulder (A4)**	1.99	–.23	3.66

Outline:

Blade: Triangular blade with straight to slightly convex edges.
Shoulder: Pronounced barb resulting from corner notching, forms an acute angle relative to the stem.
Stem: Parallel to slightly expanding, straight edges.
Base: Straight to slightly convex.

CULTURAL AFFILIATIONS Unknown Probably Late Archaic†

This type appears to be significantly different from other control types identified from the Oshara, Cochise, and Trans-Pecos areas. This type is similar in form to known types, but reflects enough variability to warrant classification as a new type. Probably distributed throughout the Tularosa Basin and adjacent areas.

REFERENCES

†Similar points identified in Beckett (1983a)

BS TYPE III
N=2
(Figure A10.14)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	—	—	—
Maximum Width (M7)	2.37	2.24	2.50
Notch Width (M5)	0.99	0.95	1.03
Shoulder Width (M4)	0.54	0.46	0.62
Haft Element Length (M3)	0.59	0.54	0.64
Maximum Basal Width (M9)	0.79	0.76	0.82
Basal Width/Height Ratio (M8)	0.68	0.64	0.72
Basal Angle (A1)**	0.13	0.20	0.16
Angle at Shoulder (A4)**	0.14	0.73	0.15

Outline:

Blade: Triangular with straight edges, evidence of systematic serration.
Shoulder: Protrudes from the stem, unbarbed with a straight edge forming a right or slightly obtuse angle relative to the stem.
Stem: Slightly contracting with straight edges, almost parallel and relatively short.
Base: Straight.

CULTURAL AFFILIATIONS Unknown Probable Late Archaic†

This type appears to be significantly different from other control types identified for the Oshara, Cochise, and Trans-Pecos areas. While similar in form to known types, BS Type III varies enough to be considered distinct.

REFERENCES

†Similar points identified in Beckett (1983a)

*Measured in cm **Measured from Horizontal

BS TYPE IV
N=19

(Figures A10.14, A10.15)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.43	2.61	4.64
Maximum Width (M7)	2.67	1.68	2.74
Notch Width (M5)	0.70	0.48	1.14
Shoulder Width (M4)	0.49	0.28	0.88
Haft Element Length (M3)	0.58	0.22	0.83
Maximum Basal Width (M9)	1.53	1.10	2.26
Basal Width/Height Ratio (M8)	1.51	0.90	3.16
Basal Angle (A1)**	0.03	0.49	0.57
Angle at Shoulder (A4)**	1.57	–.39	3.44

Outline:

Blade: Wide triangular blade with straight to slightly convex edges.
Shoulder: Pronounced barb formed by corner notch, forms an acute angle relative to stem.
Stem: Short and expanding, concave edges usually terminates at a point as wide as shoulders.
Base: Convex.

CULTURAL AFFILIATIONS Unknown Probable Late Archaic†

This type appears to be significantly different from other control types identified for the Oshara, Cochise, and Trans-Pecos areas. While some overlap in morphology may occur with other known types, BS Type IV represents a distinct type. Distribution probably extends throughout the Tularosa Basin and adjacent areas.

REFERENCES
†Similar points identified in Beckett (1983a)

BS TYPE V
N=29
(Figures A10.15, A10.16, A10.17)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.36	2.17	5.01
Maximum Width (M7)	2.39	1.22	3.36
Notch Width (M5)	1.00	0.68	1.47
Shoulder Width (M4)	0.58	0.19	0.88
Haft Element Length (M3)	0.89	0.55	1 34
Maximum Basal Width (M9)	1.71	1.10	2.32
Basal Width/Height Ratio (M8)	1.02	0.65	1.99
Basal Angle (A1)**	1.49	–.42	3.65
Angle at Shoulder (A4)**	–.02	–.37	0.41

Outline:

Blade: Triangular with straight to convex edges
Shoulders: Corner notched with prominent barbs.
Stems: Straight to expanding toward base, broader at base than at the shoulders, edges are convex only a few examples are straight.
Base: Majority of examples are subconvex, some are straight.

CULTURAL AFFILIATIONS Unknown Probable Late Archaic†

This type appears to be significantly different from other control types identified for the Oshara, Cochise, and Trans-Pecos areas. While similar in form to known types, this point varies enough to represent a distinct type. Probably distributed throughout Tularosa Basin and adjacent areas.

REFERENCES
†Similar points identified in Beckett (1983a)

BS TYPE VI
N=5
(Figure A10.17)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.52	2.85	4.39
Maximum Width (M7)	1.61	1.06	2.08
Notch Width (M5)	1.05	0.86	1.35
Shoulder Width (M4)	0.38	0.25	0.51
Haft Element Length (M3)	0.74	0.45	0.97
Maximum Basal Width (M9)	0.93	0.60	1.24
Basal Width/Height Ratio (M8)	0.74	0.34	1.39
Basal Angle (A1)**	0.21	0.13	0.41
Angle at Shoulder (A4)**	0.92	0.36	2.09

Outline:

Blade: Triangular with convex edges.
Shoulders: Pronounced, extend straight from stem no barb. Ranges between a right angle to obtuse angle.
Stem: Long and parallel.
Base: Straight.

CULTURAL AFFILIATIONS Unknown Probable Late Archaic†

This type appears to be significantly different from other control types identified for Oshara, Cochise, and Trans-Pecos areas. While similar in form to other known types, this point is distinct enough to be classified separately.

REFERENCES
†Similar points identified from Beckett (1983a)

*Measured in cm **Measured from Horizontal

SCALLORN TYPE
N=10
(Figure A10.18)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.11	1.79	4.21
Maximum Width (M7)	1.42	1.16	2.12
Notch Width (M5)	0.54	0.38	0.78
Shoulder Width (M4)	0.42	0.27	0.69
Haft Element Length (M3)	0.49	0.25	0.08
Maximum Basal Width (M9)	0.95	0.44	1.26
Basal Width/Height Ratio (M8)	1.11	0.72	2.10
Basal Angle (A1)**	0.10	-.27	0.68
Angle at Shoulder (A4)**	1.46	-.42	3.78

Outline:

Blade: Slender triangular blades with straight to convex edges.
Shoulder: Squared, occasionally barbed, forms an acute angle.
Stem: Formed by corner notches, expands to form a wedge, terminates at a point as wide as shoulders.
Base: Straight to concave.

CULTURAL AFFILIATIONS Post Archaic
Dates between 1500 and 800 years BP

Found throughout Texas and New Mexico.

REFERENCES
Suhm and Jelks (1962)
Turner and Hester (1985)

PERDIZ TYPE
N=4
(Figure A10.18)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.63	3.26	3.96
Maximum Width (M7)	1.90	1.24	2.62
Notch Width (M5)	0.97	0.80	1.16
Shoulder Width (M4)	0.50	0.30	0.74
Haft Element Length (M3)	0.74	0.59	0.90
Maximum Basal Width (M9)	0.68	0.62	0.73
Basal Width/Height Ratio (M8)	0.56	0.49	0.64
Basal Angle (A1)**	-.18	0.64	0.78
Angle at Shoulder (A4)**	2.52	0.36	3.54

Outline:

Blade: Triangular blade with straight to convex edges.
Shoulder: Straight at right angle to stem or barbed with an acute angle.
Stem: Contracts sharply to a pointed or rounded base.
Base: Pointed or rounded.

CULTURAL AFFILIATIONS Post Archaic
Dates range between 1000 to 500 years BP

Identified from Rio Grande to Red River and northeastern Trans-Pecos.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Roney (1985)
Turner and Hester (1985)

FRESNO TYPE
N=2
(Figure A10.18)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	—	—	1.20
Maximum Width (M7)	0.53	0.32	0.74
Notch Width (M5)	0.81	0.74	0.88
Shoulder Width (M4)	0.32	0.24	0.40
Haft Element Length (M3)	0.48	0.47	0.50
Maximum Basal Width (M9)	0.89	0.62	1.16
Basal Width/Height Ratio (M8)	0.95	0.63	1.28
Basal Angle (A1)**	0.17	0.06	0.27
Angle at Shoulder (A4)**	1.85	1.84	1.86

Outline:

Blade: Triangular shaped points straight to convex edges.
Shoulders: None.
Stem: None.
Base: Straight to slightly convex.

CULTURAL AFFILIATIONS Post Archaic
Dates range from 1100 to 200 years BP

Wide distribution throughout Texas, western Trans-Pecos, and northern Mexico.

REFERENCES
Suhm and Jelks (1962)
Mallouf (1985)
Turner and Hester (1985)

*Measured in cm **Measured from Horizontal

HARRELL TYPE
N=2
(Figure A10.18)

DESCRIPTION

Dimensions:	Mean*	Minimum*	Maximum*
Maximum Length (M6)	3.06	2.59	3.54
Maximum Width (M7)	1.31	1.18	1.44
Notch Width (M5)	0.40	0.37	0.44
Shoulder Width (M4)	0.35	0.28	0.42
Haft Element Length (M3)	0.32	0.19	0.45
Maximum Basal Width (M9)	1.30	1.26	1.34
Basal Width/Height Ratio (M8)	2.39	1.50	3.28
Basal Angle (A1)**	0.05	—	0.10
Angle at Shoulder (A4)**	1.90	1.09	2.72

Outline:

Blade: Triangular with straight to convex edges.
Shoulder: Shoulder defined by pronounced side notching.
Stem: Straight to expanding, as wide or wider than blade.
Base: Either a deep basal notch or straight.

CULTURAL AFFILIATIONS Post Archaic

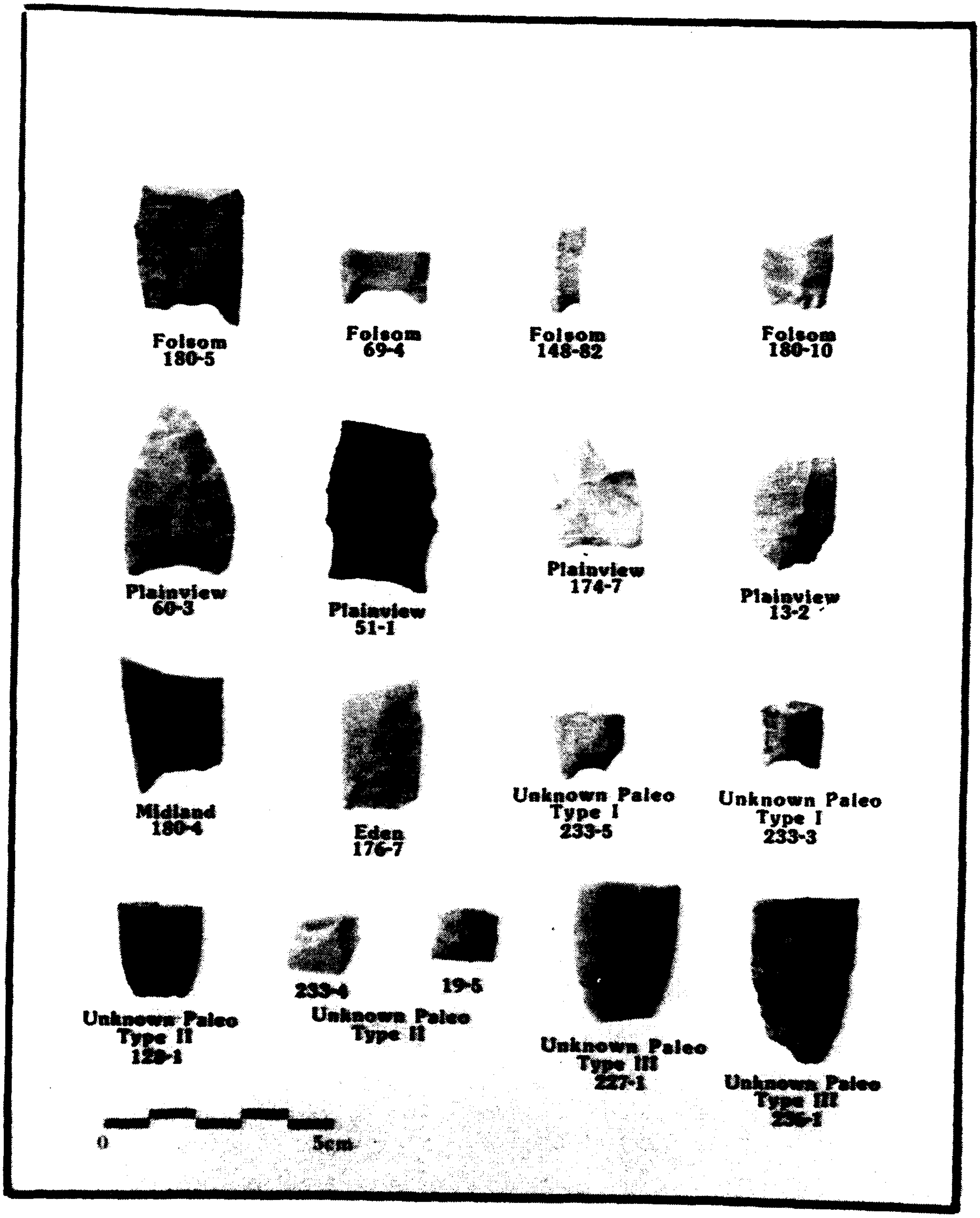
Dates range between 900 and 500 years BP

Distributed from northern Texas to Canada, from the Mississippi Valley to the Southwest.

REFERENCES

Suhm and Jelks (1962)
Mallouf (1985)
Turner and Hester (1985)

*Measured in cm **Measured from Horizontal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174-7
Plainview
13-2
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180-4
Eden
176-7
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Type I
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Type I
233-3
233-4
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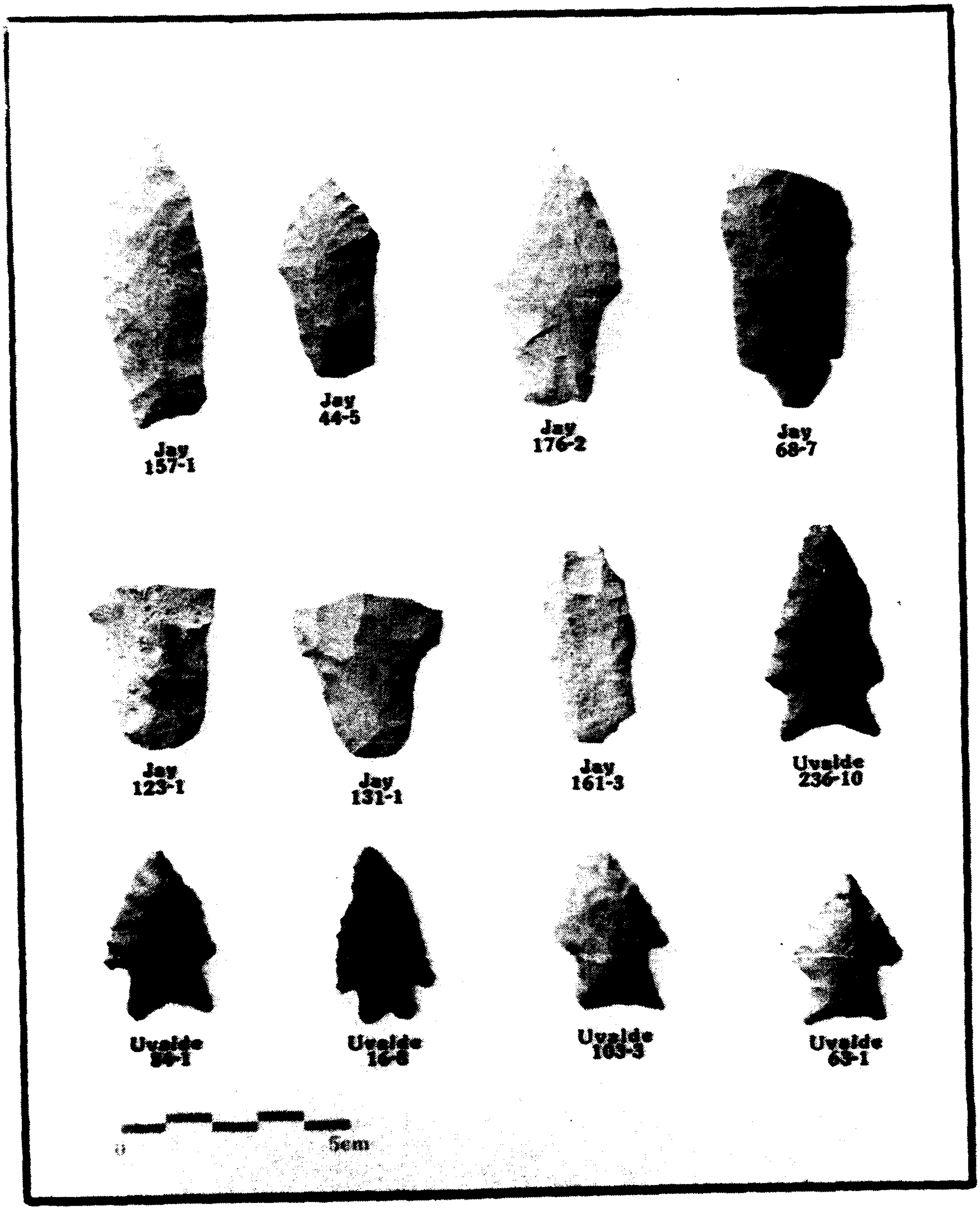
Figure A10.1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Uvalde
63-1
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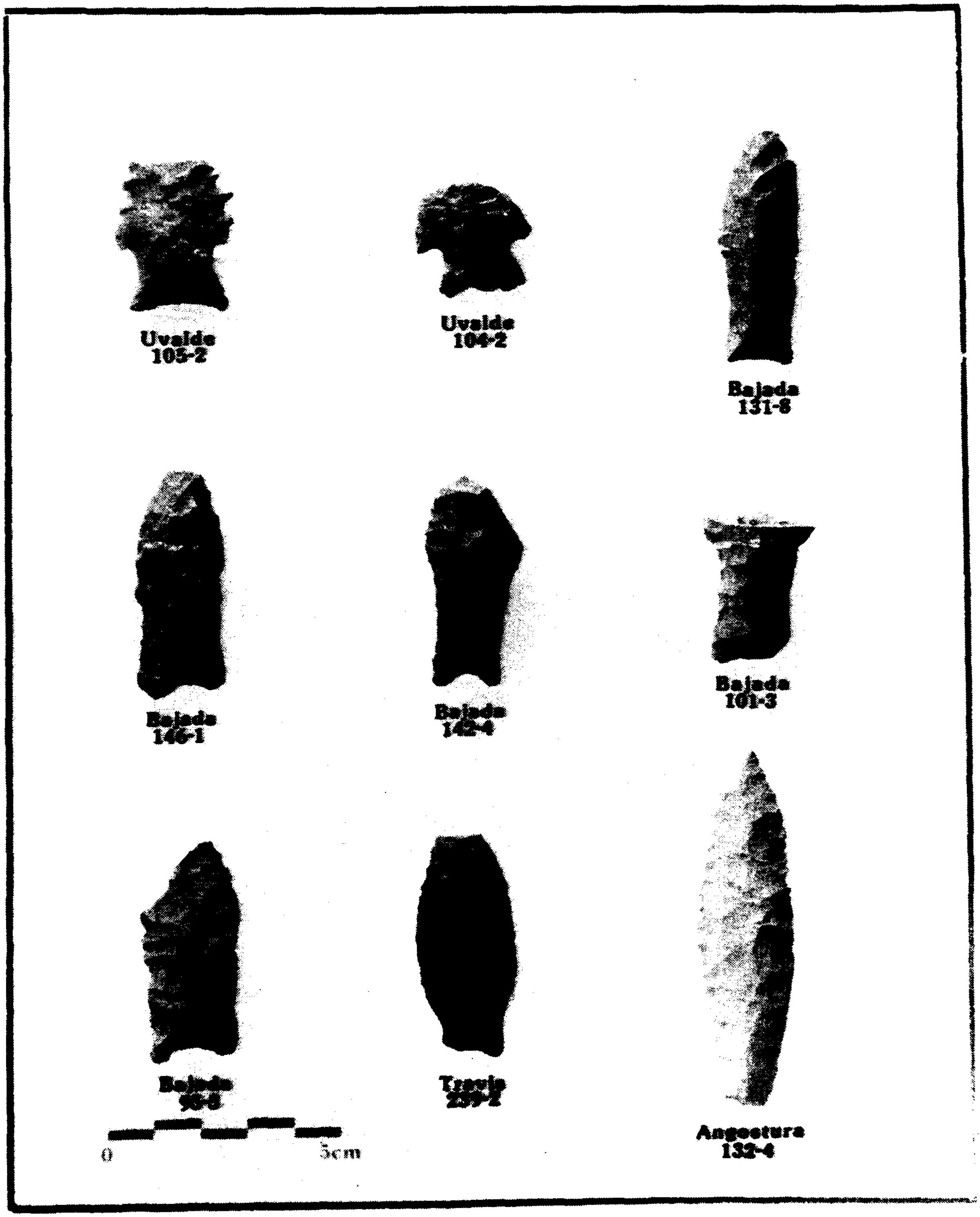
Figure A10.2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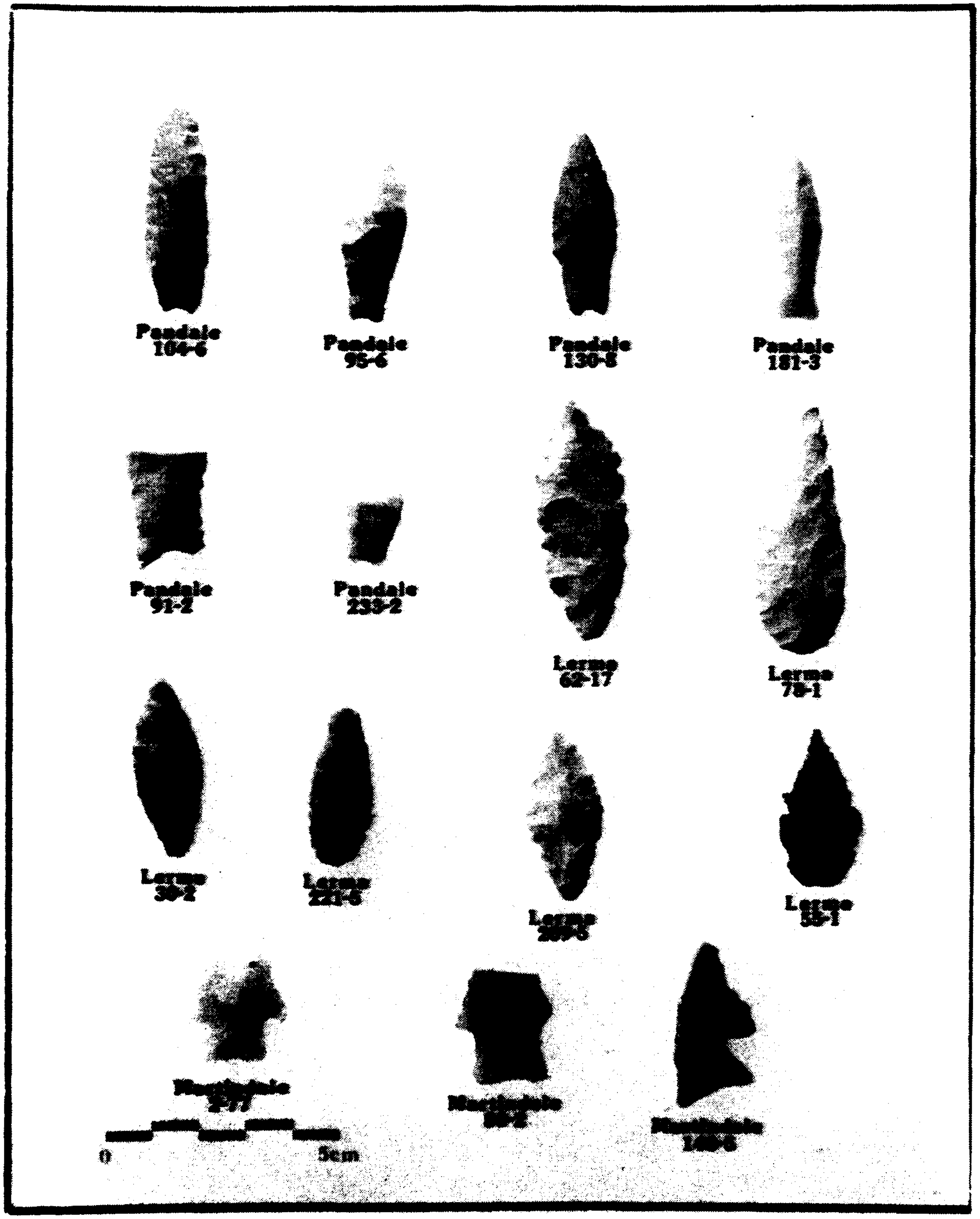
5cm
Angostura
132-4

Figure A10.3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Lerma
62-17
Lerma
78-1
Lerma
30-2
Lerma
221-5
Lerma
Lerma
55-1
0
5cm

Figure A10.4

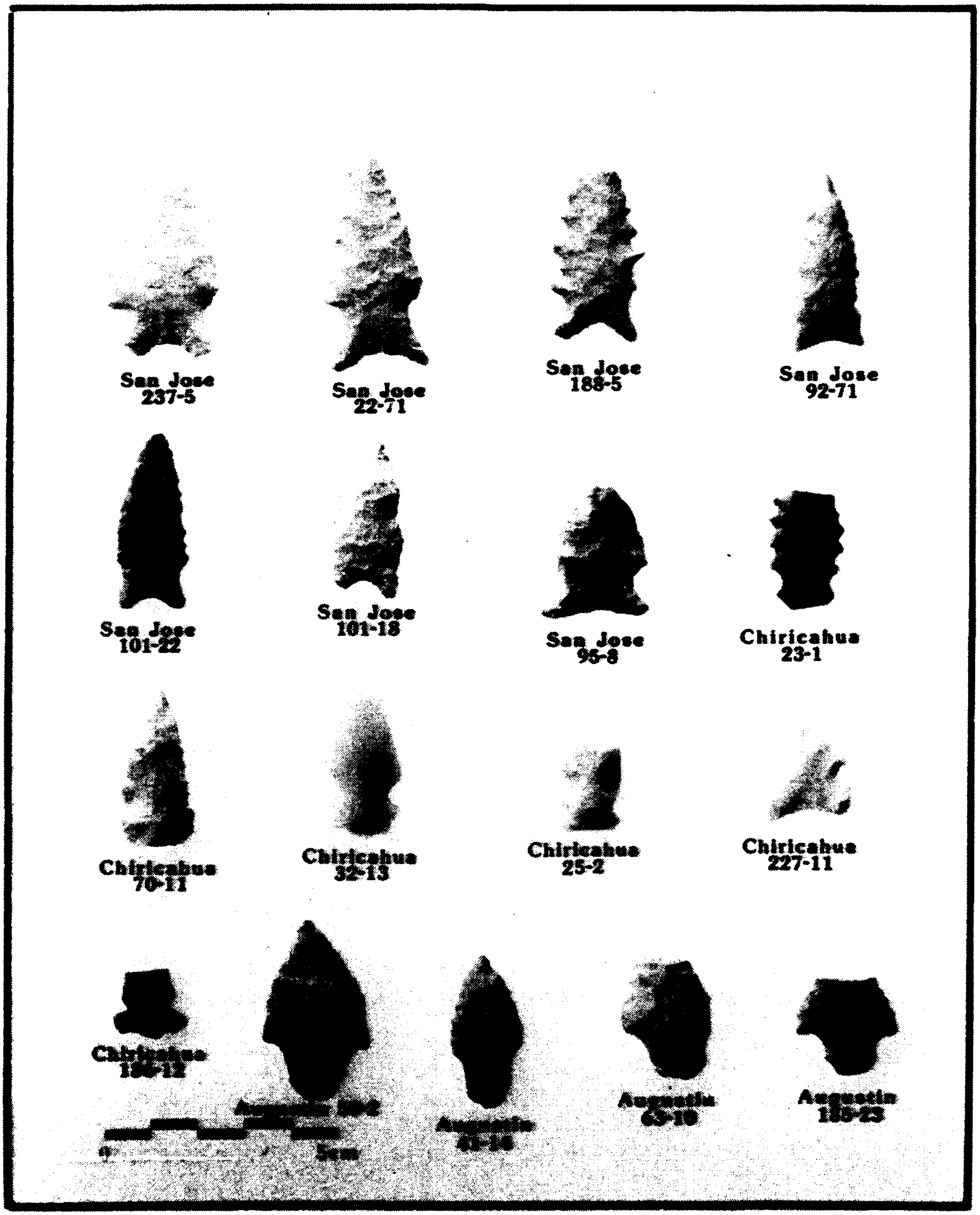

San Jose 237-5
San Jose 22-71
San Jose 188-5
San Jose 92-71
San Jose 101-22
San Jose 101-18
San Jose 95-8
Chiricahua 23-1
Chiricahua 70-11
Chiricahua 32-13
Chiricahua 25-2
Chiricahua 227-11
Chiricahua
Augustin
Augustin 65-10
Augustin
5cm

Figure A10.5

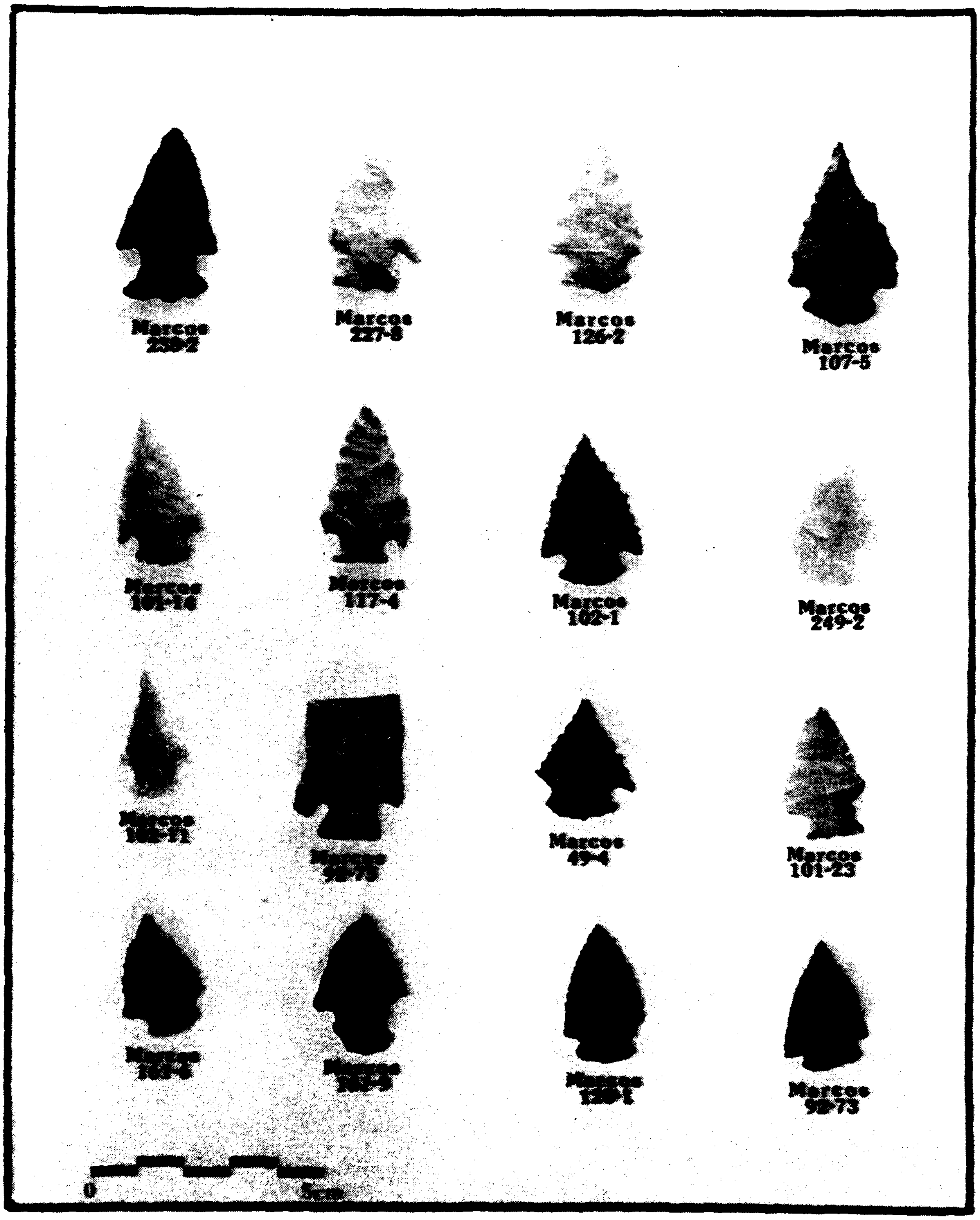
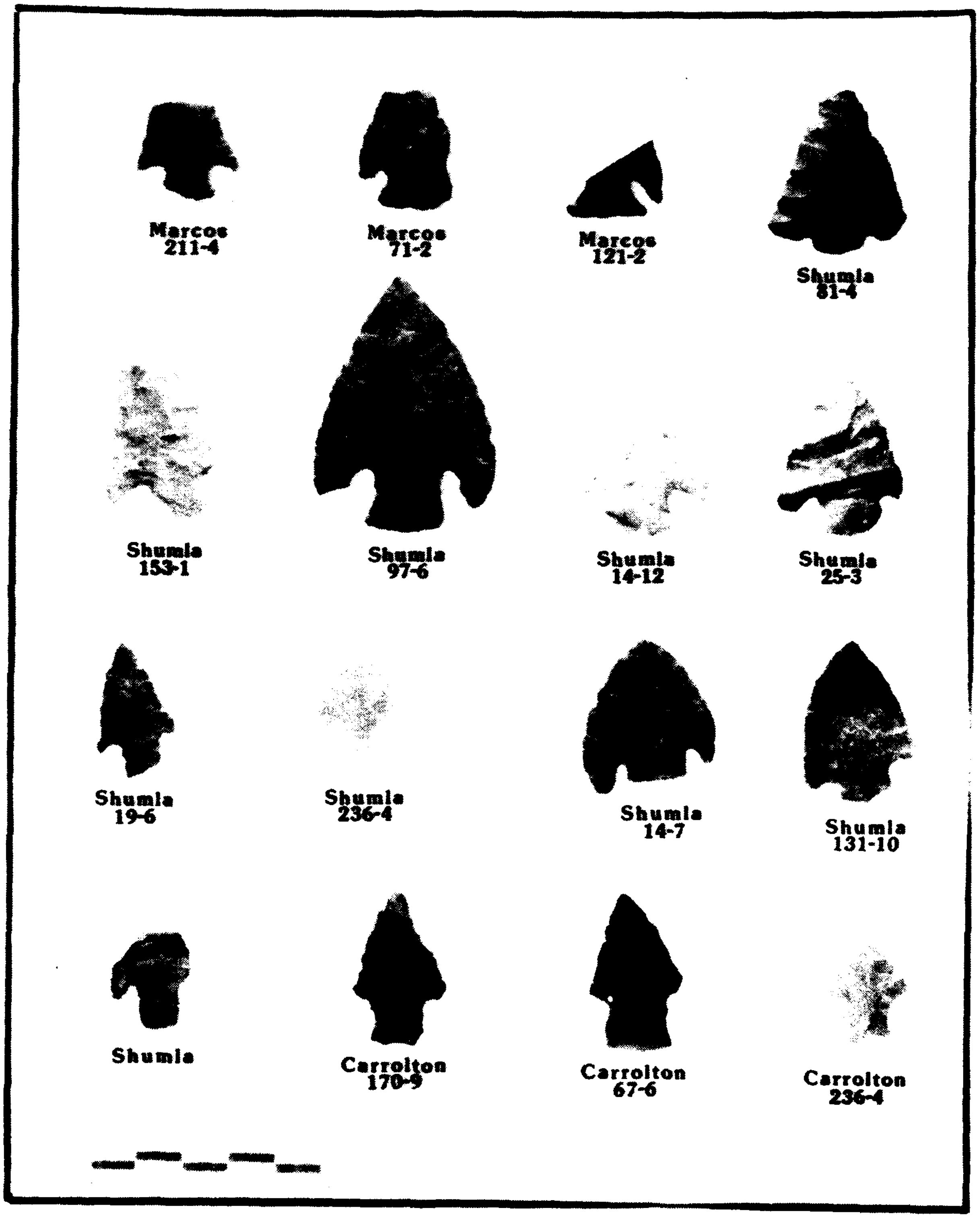

Marcos
227-8
Marcos
126-2
Marcos
107-5
Marcos
117-4
Marcos
102-1
Marcos
249-2
Marcos
49-4
Marcos
101-23
Marcos
92-73
0

Figure A10.6



Marcos
211-4
Marcos
71-2
Marcos
121-2
Shumla
81-4
Shumla
153-1
Shumla
97-6
Shumla
14-12
Shumla
25-3
Shumla
19-6
Shumla
236-4
Shumla
14-7
Shumla
131-10
Shumla
Carrolton
170-9
Carrolton
67-6
Carrolton
236-4

Figure A10.7

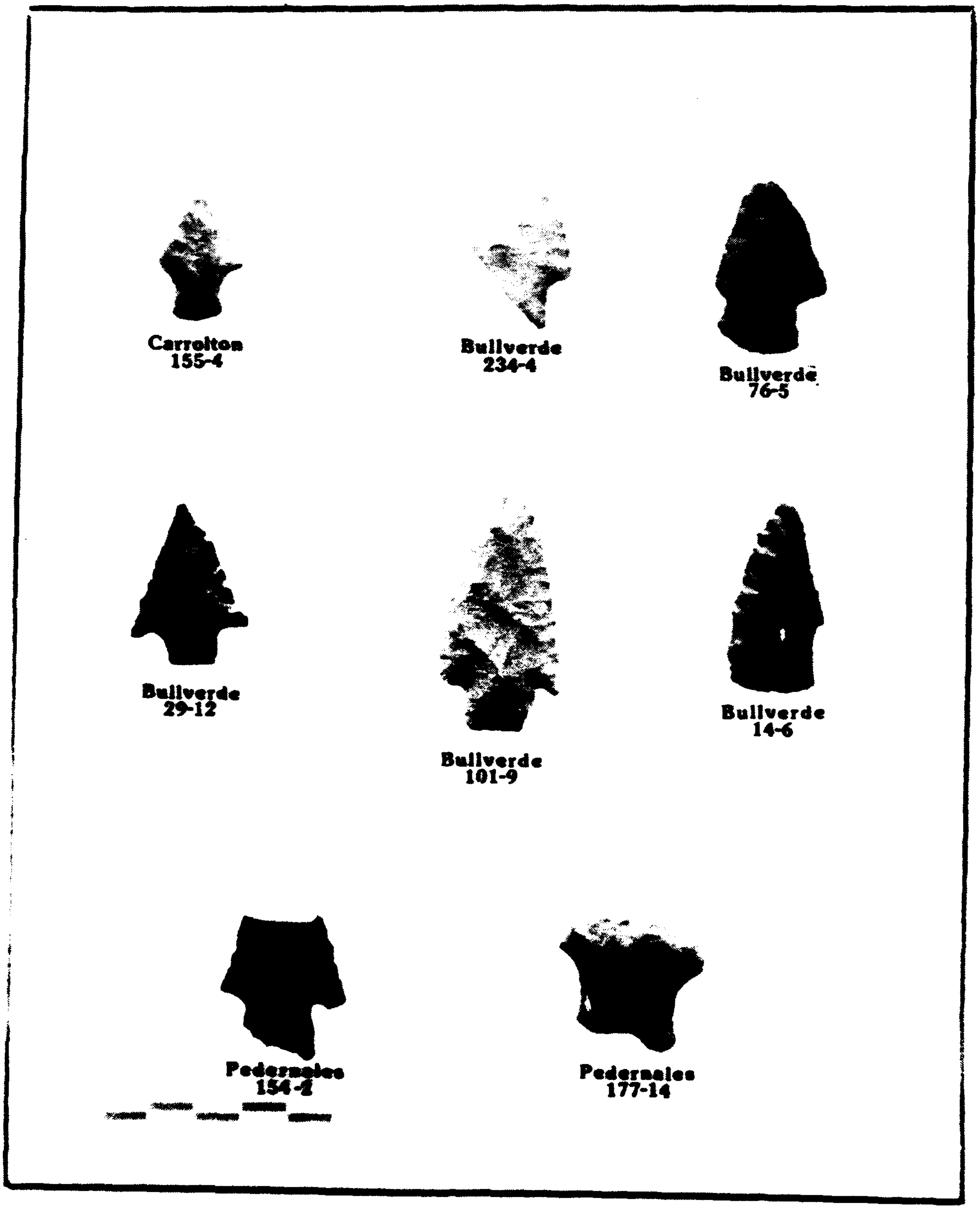

Carrolton
155-4
Bullverde
234-4
Bullverde
76-5
Bullverde
29-12
Bullverde
101-9
Bullverde
14-6
Pedernales
154-2
Pedernales
177-14

Figure A10.8

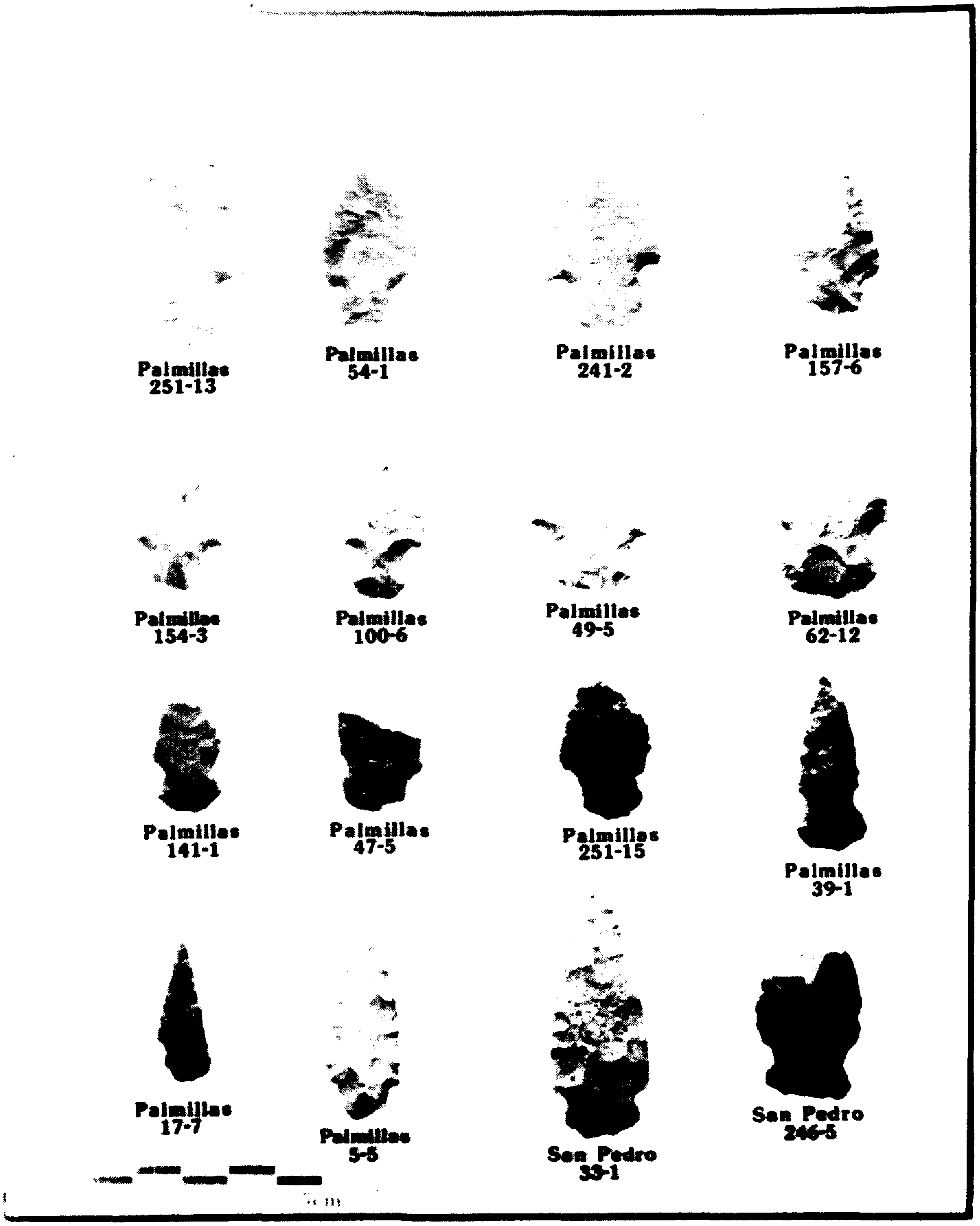

Palmillas 251-13
Palmillas 54-1
Palmillas 241-2
Palmillas 157-6
Palmillas 154-3
Palmillas 100-6
Palmillas 49-5
Palmillas 62-12
Palmillas 141-1
Palmillas 47-5
Palmillas 251-15
Palmillas 39-1
Palmillas 17-7
Palmillas 5-5
San Pedro 33-1
San Pedro 246-5

Figure A10.9

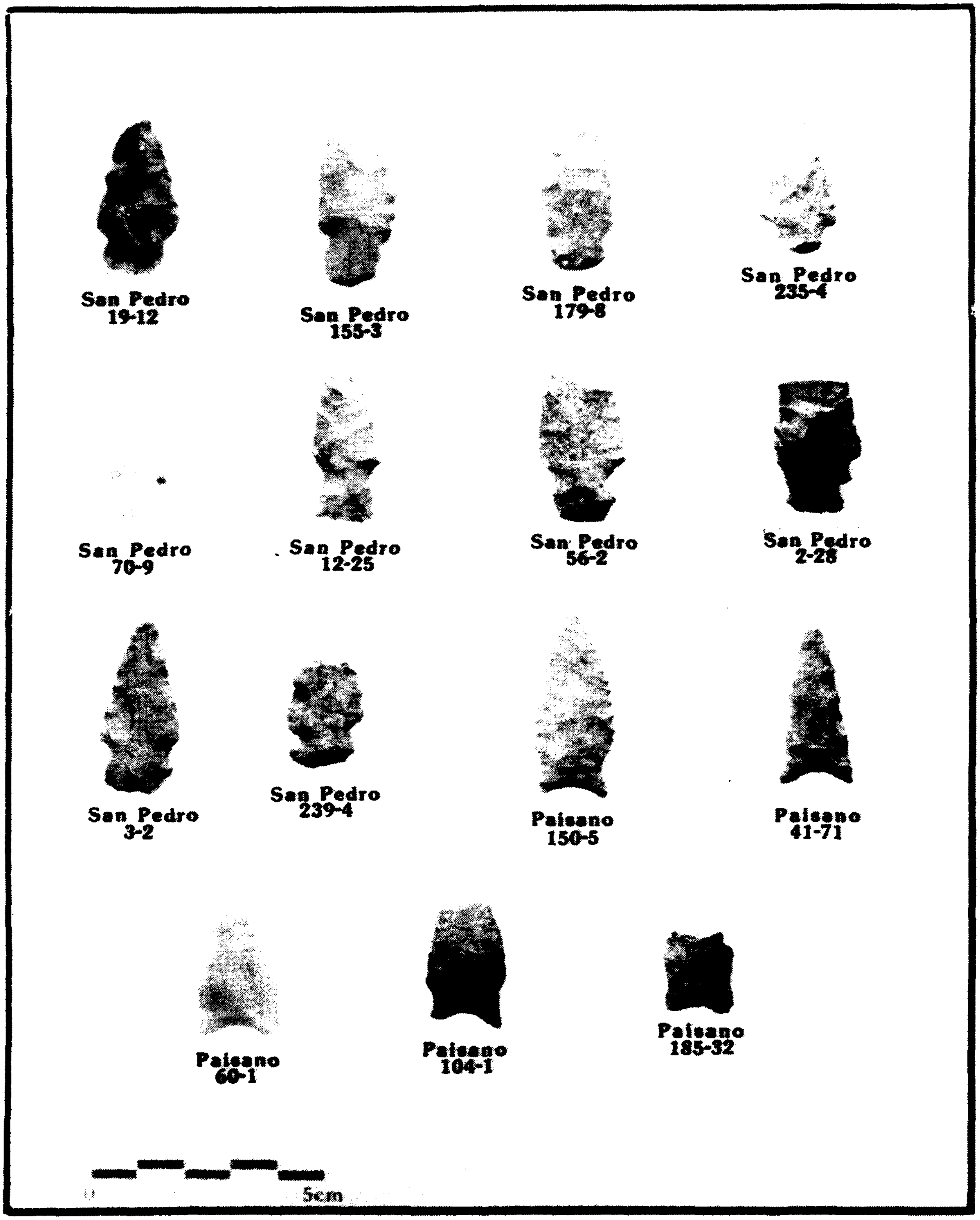


Figure A10.10

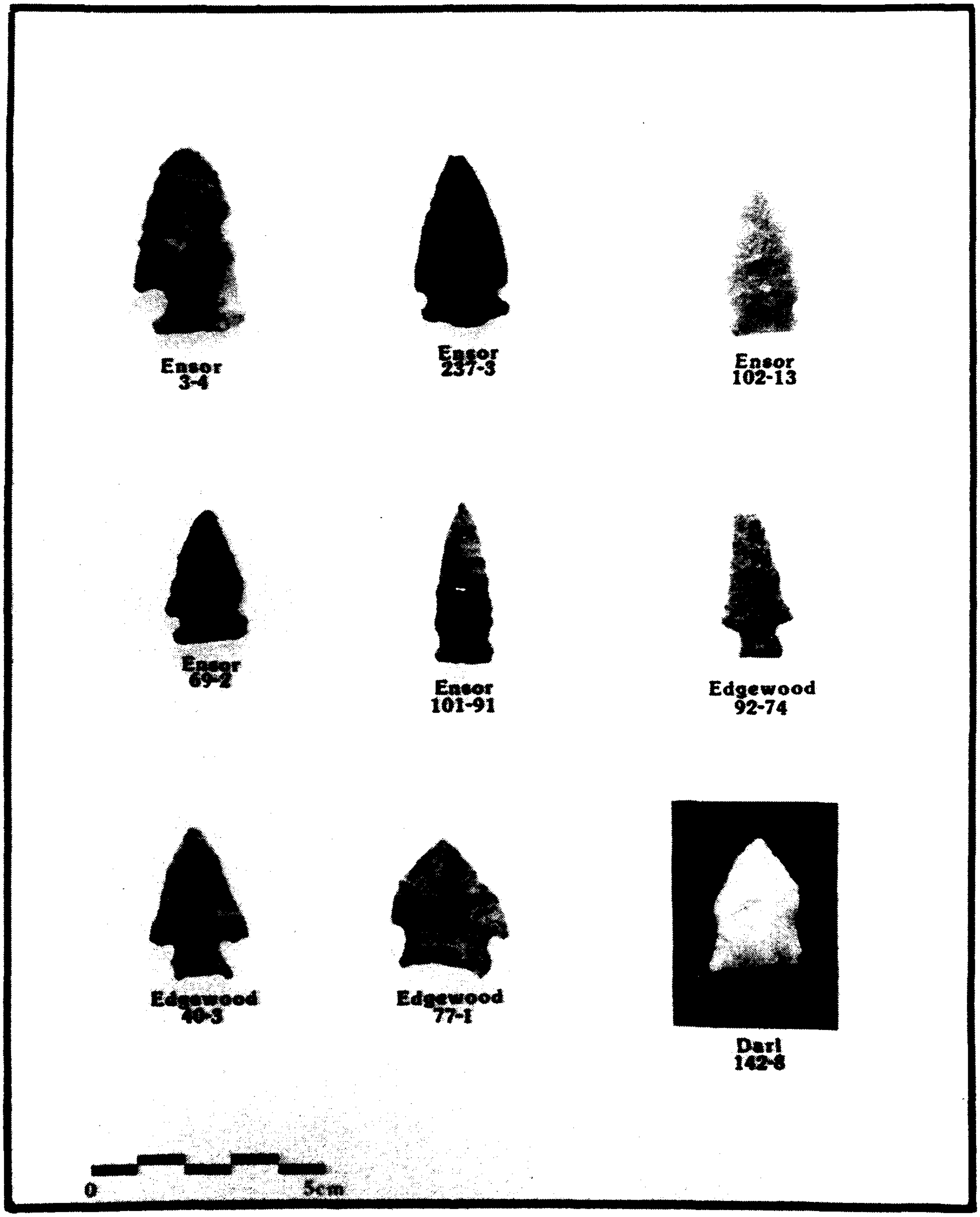


Figure A10.11

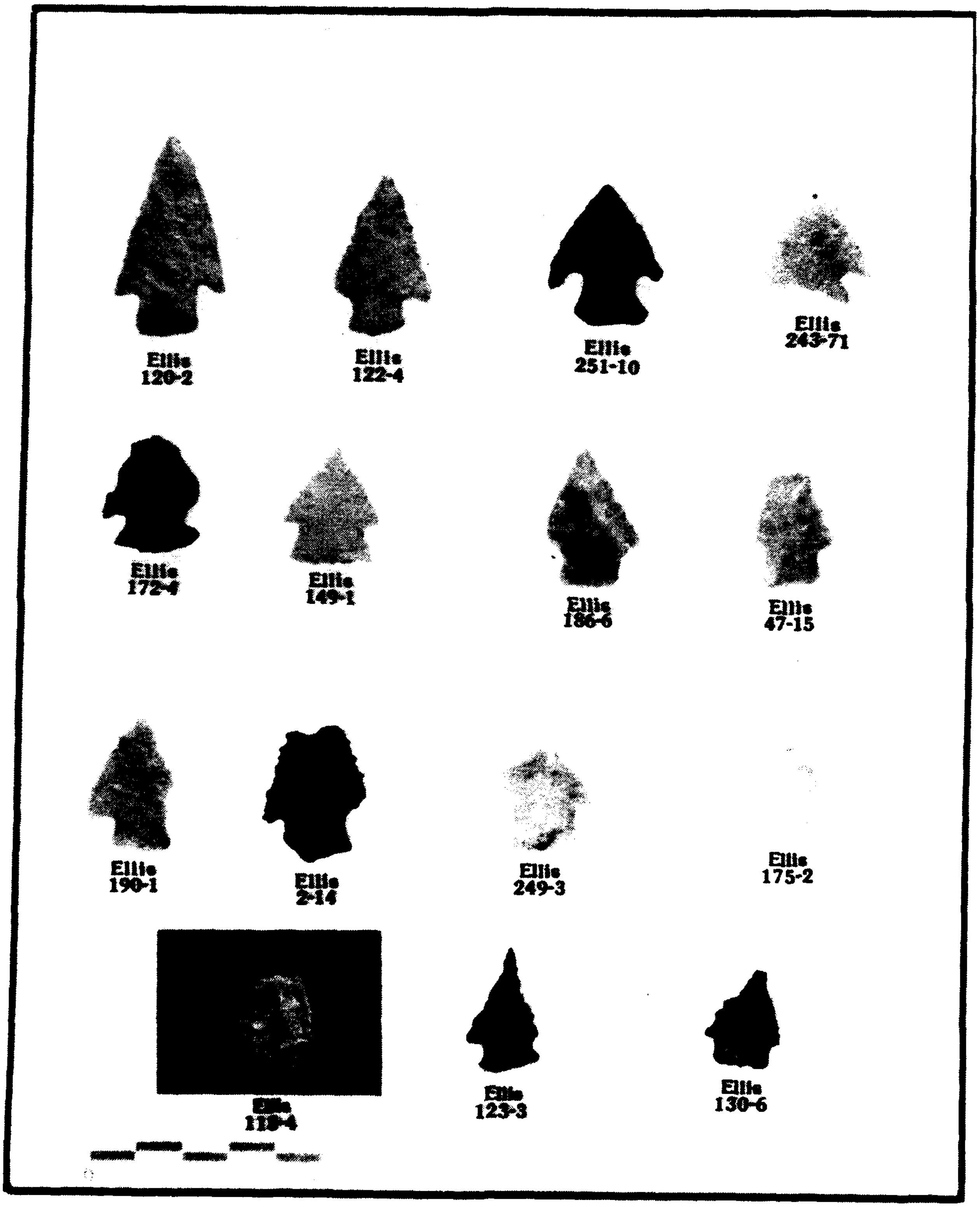


Figure A10.12

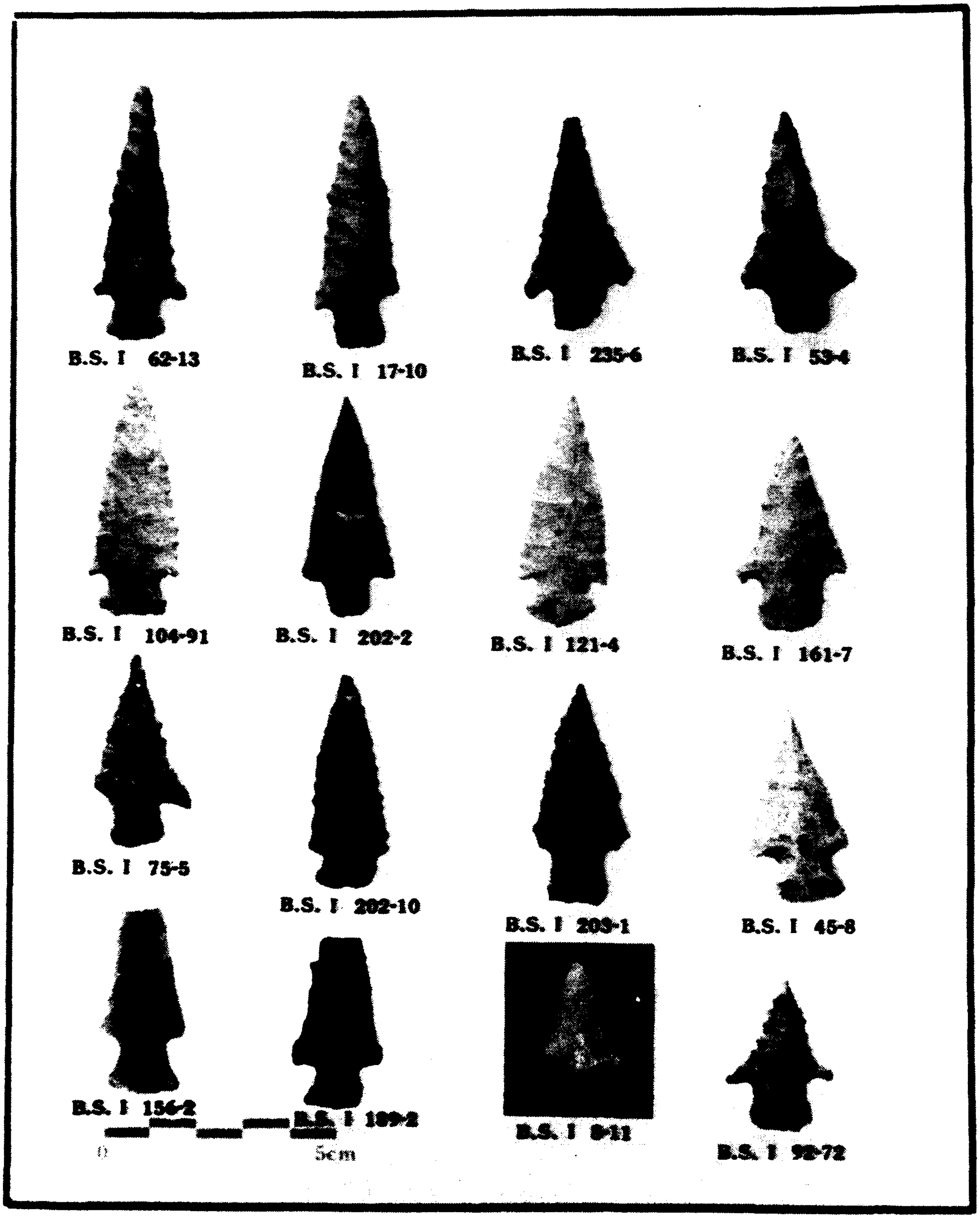


Figure A10.13

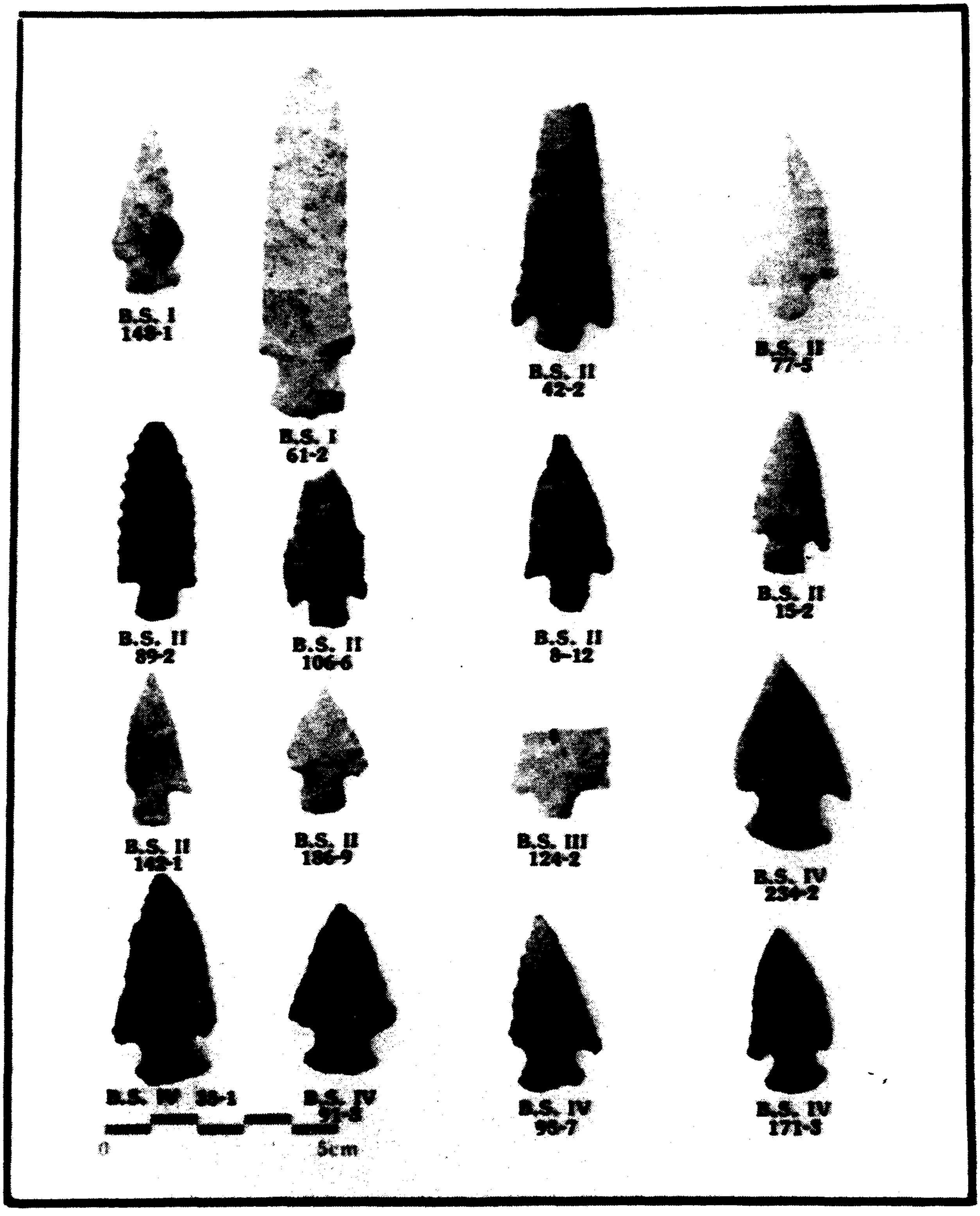


Figure A10.14

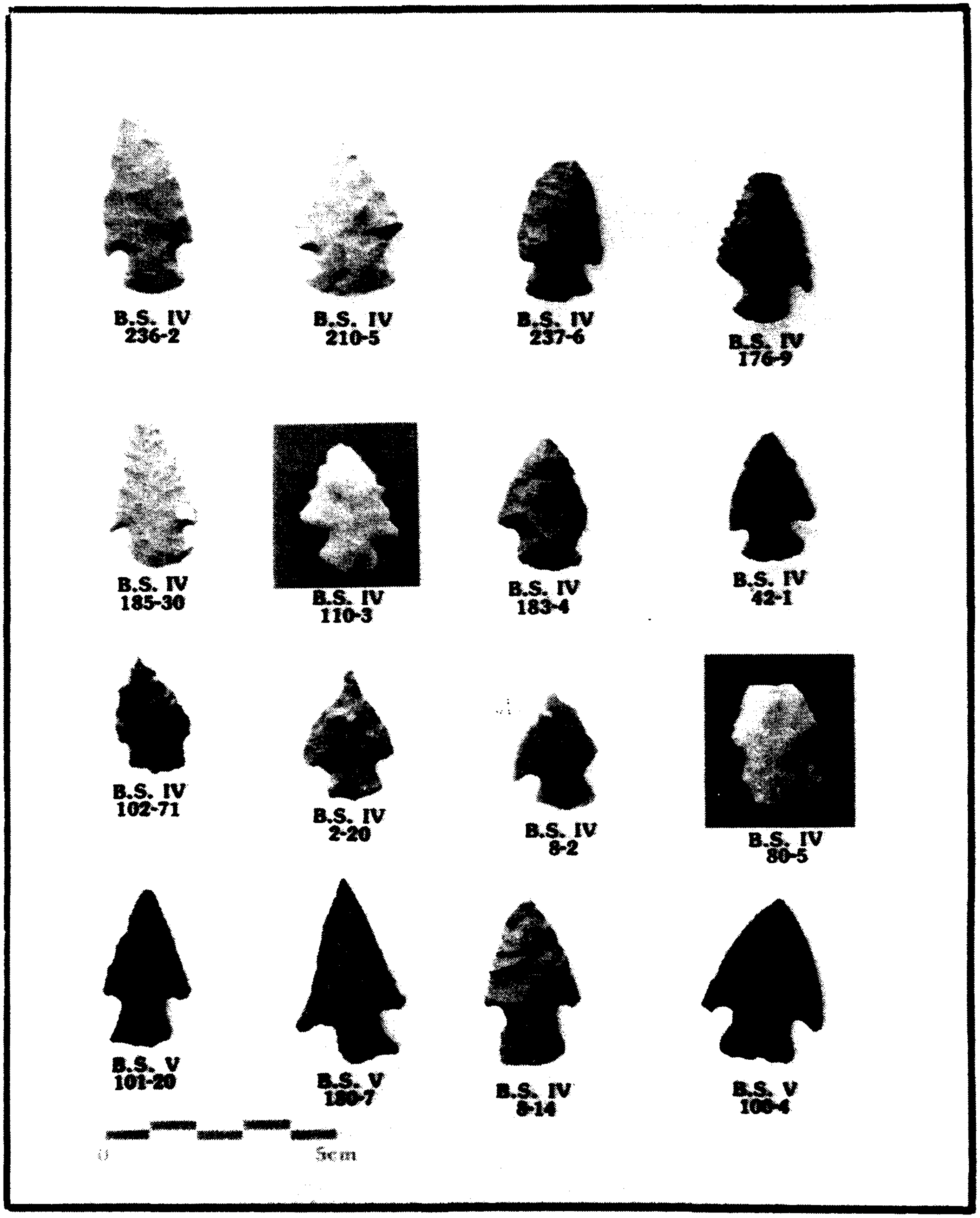


Figure A10.15

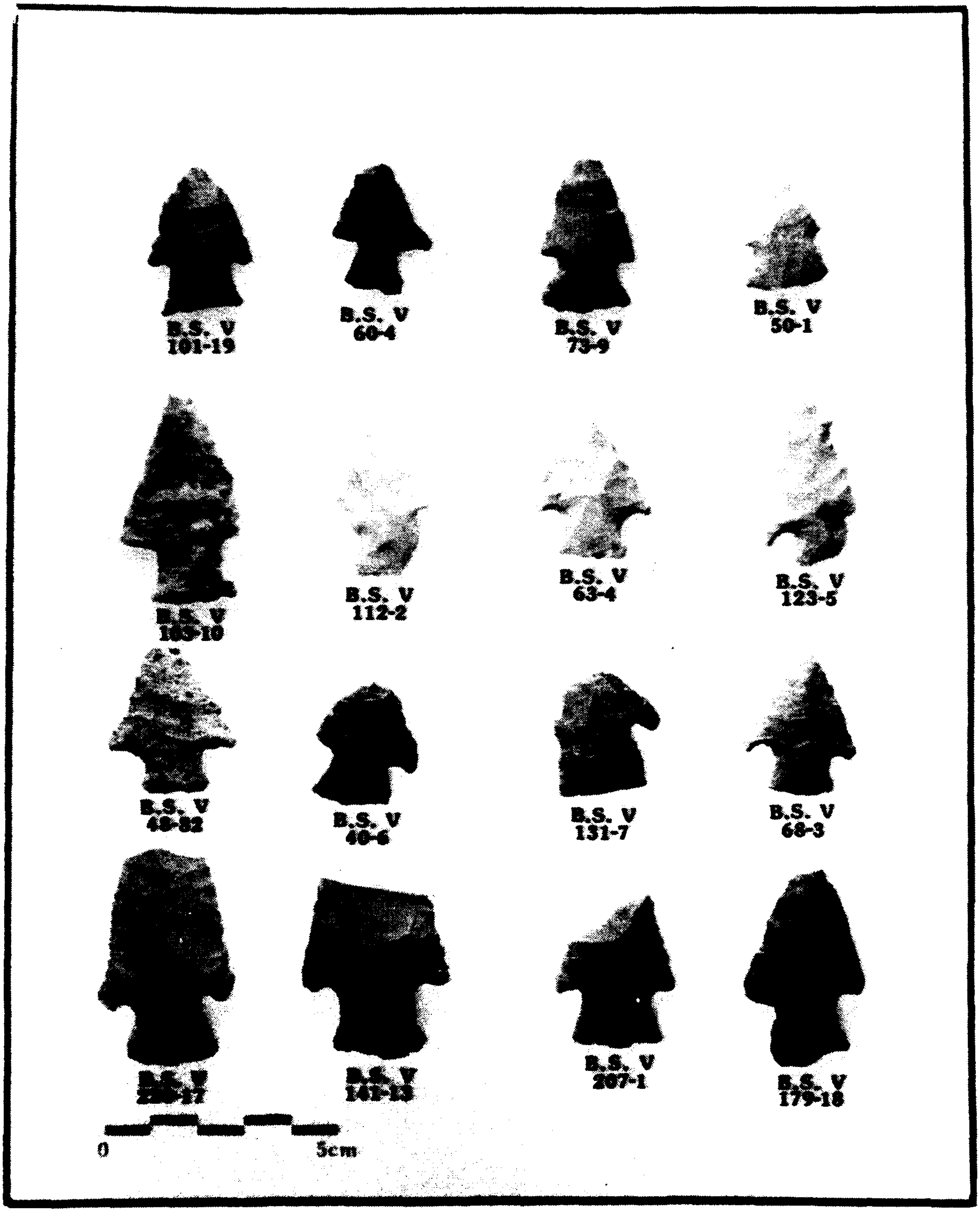


Figure A10.16

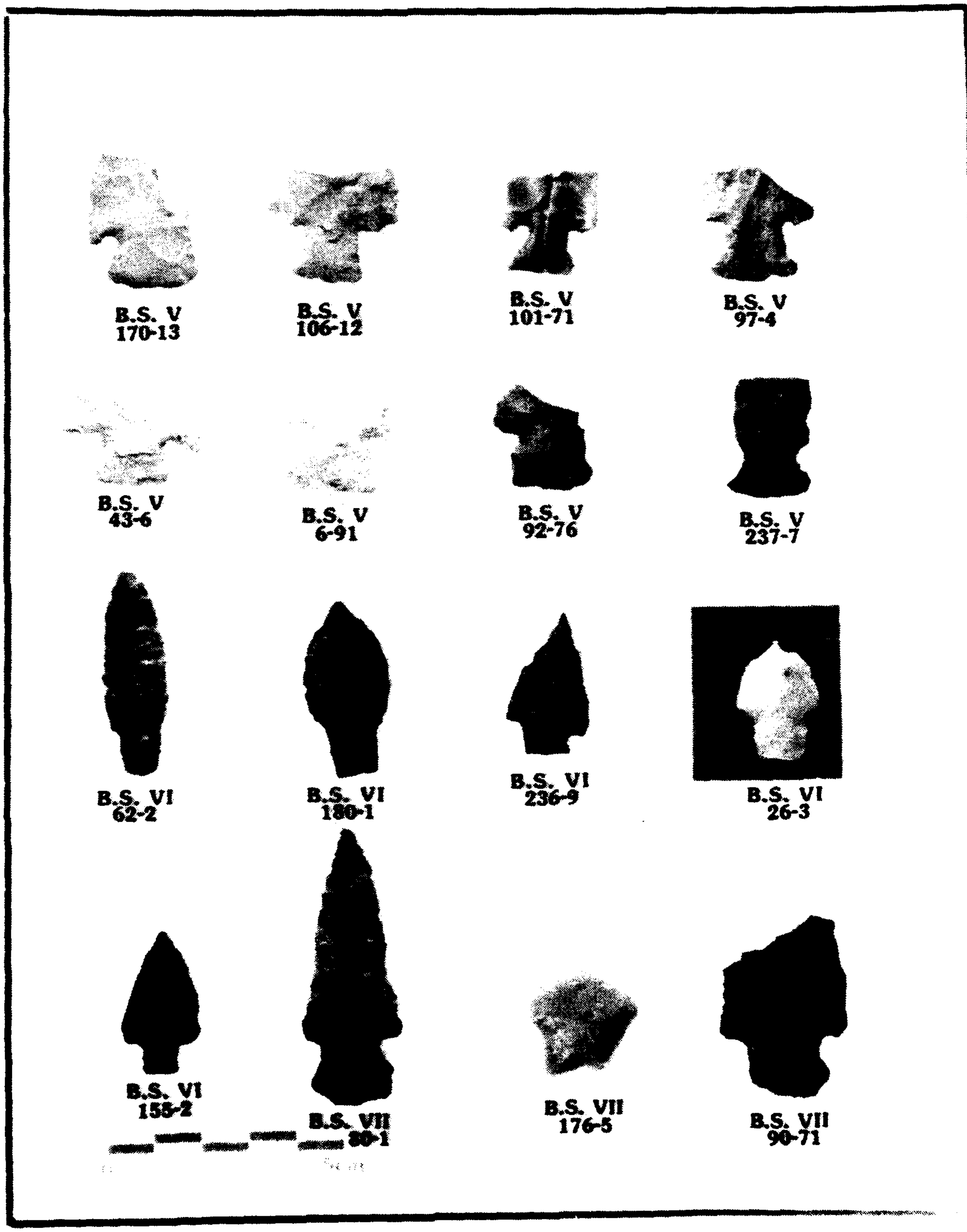


Figure A10.17

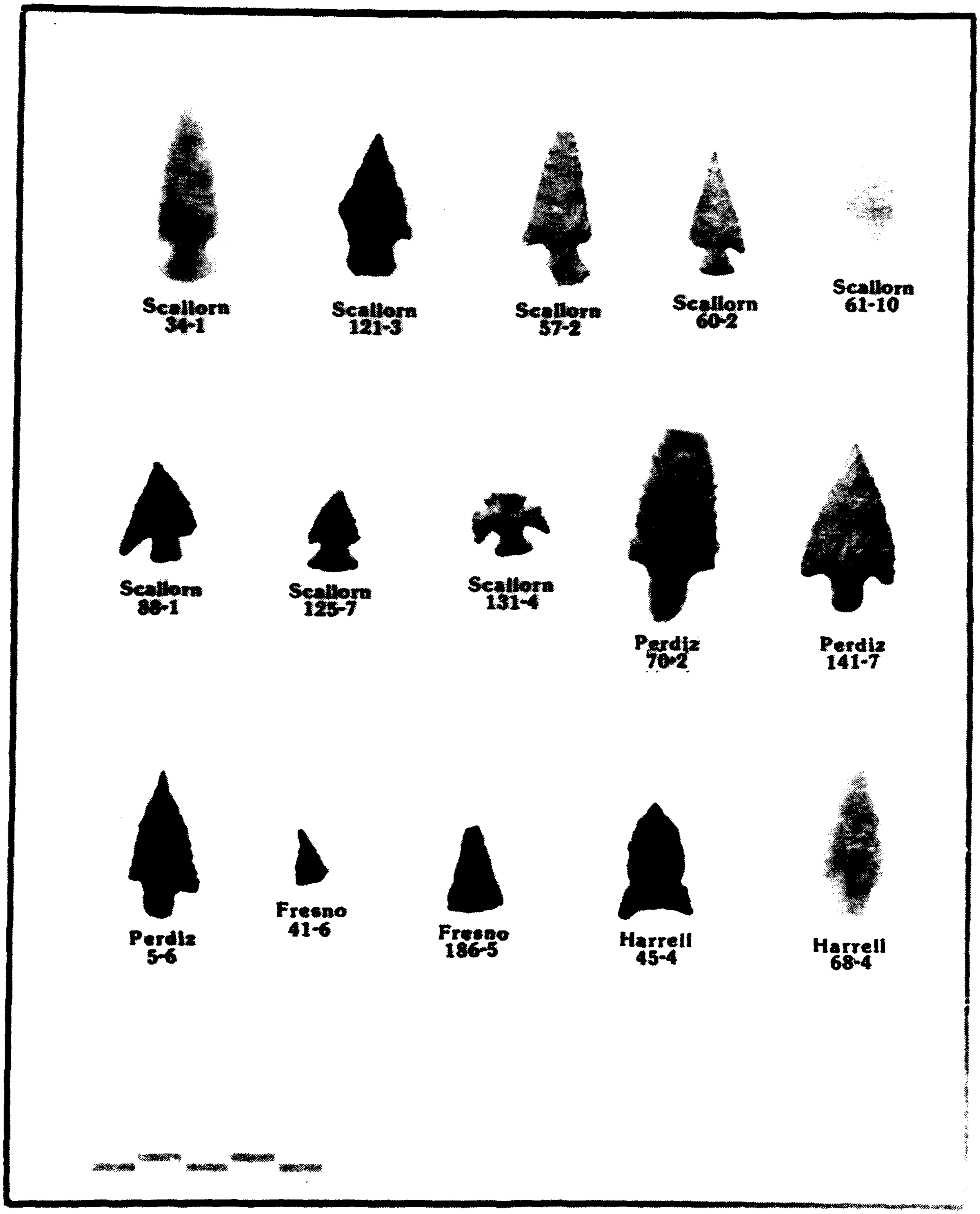


Figure A10.18

Appendix 11

TOOL DATA FROM LA 63880

Janette M. Elyea

Table A11.1 presents data concerning the lithic tool assemblage from LA 63880, a large Paleoindian site discovered during Phase I survey. The data support discussions in Chapter 17.

Table A11.1. Tool data from LA63880

CAT	MAT	UL	UD	UR	UP	LL	LD	LR	LP	DA	FC	TC	S	O
1	1660	23	33	23	0	18	21	21	0	10	5	5	2	
2	1032	43	33	23	0	18	18	19	9	5	5	5	2	
†3	3050	0	0	0	0	0	0	0	0	0	0	0	0	
4	1660	23	23	33	1	48	22	24	0	50	4	4	0	
5	1233	23	33	32	42	17	24	25	13	42	1	5	0	
6	1032	23	33	23	0	22	22	24	0	50	5	5	2	
7	1060	0	33	43	0	0	24	14	0	52	5	5	0	
8	1060	23	33	0	0	*15	*11	*00	*00	0	4	1	0	
†9	1233	22	33	25	0	19	22	22	0	10	5	5	1	
10	1032	23	33	23	11	16	17	20	0	20	6	5	0	
11	1032	23	33	23	14	20	20	19	5	39	5	5	1	
†12	1500	0	0	0	0	0	0	0	0	0	0	0	0	
13	1233	0	12	0	0	*00	*16	*00	*00	0	4	1	0	
14	1032	23	33	33	33	19	19	11	14	20	3	5	0	
15	1032	33	13	0	0	26	17	*00	*00	0	4	6	0	
16	1233	23	23	23	53	18	19	20	5	42	5	5	0	
17	1032	25	33	33	0	17	27	11	0	50	5	5	0	
18	1072	54	0	54	0	9	*00	7	*00	0	3	5	0	D
†19	1043	23	33	23	42	19	26	19	7	40	5	5	1	
20	1233	23	33	43	0	22	26	11	0	48	6	5	0	D
21	1060	23	33	43	33	21	28	22	12	36	1	5	2	
22	1210	33	13	0	0	*18	*11	*00	*00	0	1	1	0	
23	1660	23	33	23	23	19	22	22	6	62	5	5	2	
24	1233	0	35	0	0	*00	*20	*00	*00	0	4	1	0	
25	1233	0	0	13	0	*00	*00	*07	*00	0	2	1	0	
26	1630	0	0	13	0	*00	*00	*10	*00	0	2	1	0	
27	1233	0	33	0	0	*00	*22	*00	*00	0	4	4	0	
28	1032	0	33	0	0	*00	*17	*00	*00	0	4	4	0	
29	1032	32	13	0	0	*19	*07	*00	*00	0	1	1	0	
30	1032	23	33	33	0	*11	22	22	*00	70	4	4	1	
31	1032	0	33	0	0	*00	*25	*00	*00	0	1	1	0	
†32	1032	22	0	42	0	26	*00	16	*00	0	5	1	0	
33	1233	23	33	23	53	21	20	22	7	20	4	5	0	
34	1032	12	33	12	0	*04	20	*05	0	0	4	4	0	
35	1043	43	0	0	0	9	0	0	0	0	1	5	0	
36	1032	23	33	43	0	*16	16	*14	*00	35	4	4	2	
37	1233	23	0	0	0	*16	*00	*00	*00	0	1	1	0	
38	1032	23	33	23	0	*16	17	*19	*00	16	4	1	0	
39	1032	33	33	23	33	21	21	19	8	22	5	5	0	
†40	1210	22	33	22	33	17	25	18	13	20	5	5	1	
41	1032	0	23	0	23	*00	*13	*00	*13	0	1	1	0	
42	1032	23	33	22	0	*22	20	*13	*00	0	4	1	0	
43	1660	23	33	23	0	21	28	16	0	42	5	5	2	
44	1660	33	43	53	0	32	34	13	*00	0	4	1	0	
45	1032	23	0	23	0	*16	*00	*13	*00	0	3	1	0	

CAT	MAT	UL	UD	UR	UP	LL	LD	LR	LP	DA	FC	TC	S	O
46	1032	0	33	0	0	*00	26	*00	*00	0	4	4	0	
47	1032	42	33	42	0	*14	16	*20	*00	0	4	1	0	F
48	1060	43	33	23	0	22	27	28	0	50	5	5	2	
49	1032	0	33	0	0	*00	*23	*00	*00	0	4	4	0	
50	1053	0	33	0	0	*00	*15	*00	*00	0	4	1	0	
†51	1032	23	33	23	0	18	21	16	0	32	5	5	1	
52	1660	22	33	22	0	14	18	19	*00	35	4	4	1	
53	1032	33	33	0	0	*14	15	*00	*00	0	4	4	0	
54	1032	12	23	23	0	*06	20	*15	0	0	4	4	0	
55	1032	25	32	22	22	15	19	17	11	10	5	5	1	V
56	1032	23	33	43	0	24	22	7	0	30	5	5	1	V
57	1032	42	33	0	0	*08	*19	*00	*00	0	4	4	1	
58	1032	0	53	22	0	*00	*11	19	0	0	5	5	0	
59	1660	32	0	23	0	21	0	24	0	0	5	5	0	
60	1052	32	0	23	0	*24	*00	*26	*00	0	3	1	0	
61	1032	23	33	22	0	22	18	24	0	0	5	5	1	
62	1032	23	33	23	23	15	18	16	15	12	3	5	2	
†63	1032	23	53	0	0	*08	15	*00	*00	0	1	1	0	
64	1032	43	33	0	22	*06	*16	*00	*11	0	1	5	0	
65	1233	0	33	0	0	*00	*26	*00	*00	0	4	4	0	
66	1233	0	33	23	23	0	19	16	16	10	5	5	0	
†67	1032	0	0	0	0	0	0	0	0	0	1	1	0	
68	1233	0	33	43	53	0	17	8	8	22	1	5	0	
69	1032	0	33	33	0	0	22	22	0	60	5	5	0	V
70	1032	23	33	23	0	19	22	19	0	60	5	5	1	
71	1072	0	33	0	0	*00	*15	*00	*00	0	1	1	0	
†72	1660	23	33	23	53	22	18	19	5	50	5	5	1	
73	1032	33	33	23	0	*18	20	*20	*00	20	4	4	0	
†74	1233	33	33	33	33	18	22	18	18	0	1	5	1	
75	1032	23	33	23	0	21	22	16	*00	40	5	5	0	
76	1630	13	33	13	33	*09	19	*11	8	51	1	1	0	
77	1032	32	33	0	0	22	19	0	0	10	5	5	0	
78	1032	23	0	65	0	30	*00	27	0	0	2	2	0	
79	1052	0	33	65	0	0	24	20	0	48	5	5	2	V
80	1660	42	32	22	0	18	70	32	0	0	5	5	0	
81	1032	23	0	0	0	*24	*00	*00	*00	0	3	3	0	B
82	1072	32	33	23	0	*13	22	*18	*00	35	4	4	2	B
†83	1072	23	33	33	42	19	26	24	9	51	5	5	1	
84	1233	33	33	23	0	23	21	24	0	42	5	5	0	
85	1060	23	23	0	0	*18	*17	*00	*00	0	1	1	1	F
†86	1072	33	33	23	0	22	22	22	0	24	5	5	0	
87	1032	43	0	0	0	14	0	0	0	0	1	5	0	
88	1052	23	33	23	1	*09	19	*14	*00	29	5	5	1	B
89	1233	23	0	0	0	*09	*00	*00	*00	0	1	1	0	
90	1032	65	33	65	0	16	21	15	0	20	5	5	2	
91	1032	65	33	23	0	19	21	24	0	51	5	5	1	B
92	1032	23	33	65	43	20	17	18	7	32	5	5	1	
†93	1052	23	33	0	0	17	23	*00	*00	0	5	1	1	B
94	1032	55	33	23	23	11	22	19	6	0	3	5	2	
95	1032	0	0	23	43	0	*00	15	8	0	1	1	0	
96	1233	0	33	65	52	*00	21	24	10	49	5	1	1	
97	1233	53	65	0	0	18	*28	*00	*00	0	3	1	0	B
98	1072	33	43	33	0	*17	11	*20	*00	0	5	5	0	B
99	1043	33	33	23	0	16	15	19	*00	39	5	5	1	
100	1233	65	33	23	0	18	27	17	0	10	5	5	2	
†101	1032	43	33	33	53	13	19	18	9	50	5	5	2	
102	1072	23	0	0	0	*16	*00	*00	*00	0	1	1	0	
103	1233	23	0	0	0	*19	*00	*00	0	19	2	2	0	B
104	1032	23	33	0	0	19	18	0	*00	20	4	5	0	V
105	1630	43	53	0	0	12	4	0	0	0	1	1	0	
106	1072	23	33	23	33	18	27	28	8	40	5	5	2	
107	1032	52	23	0	33	21	11	*00	22	10	4	5	2	

APPENDIX 11

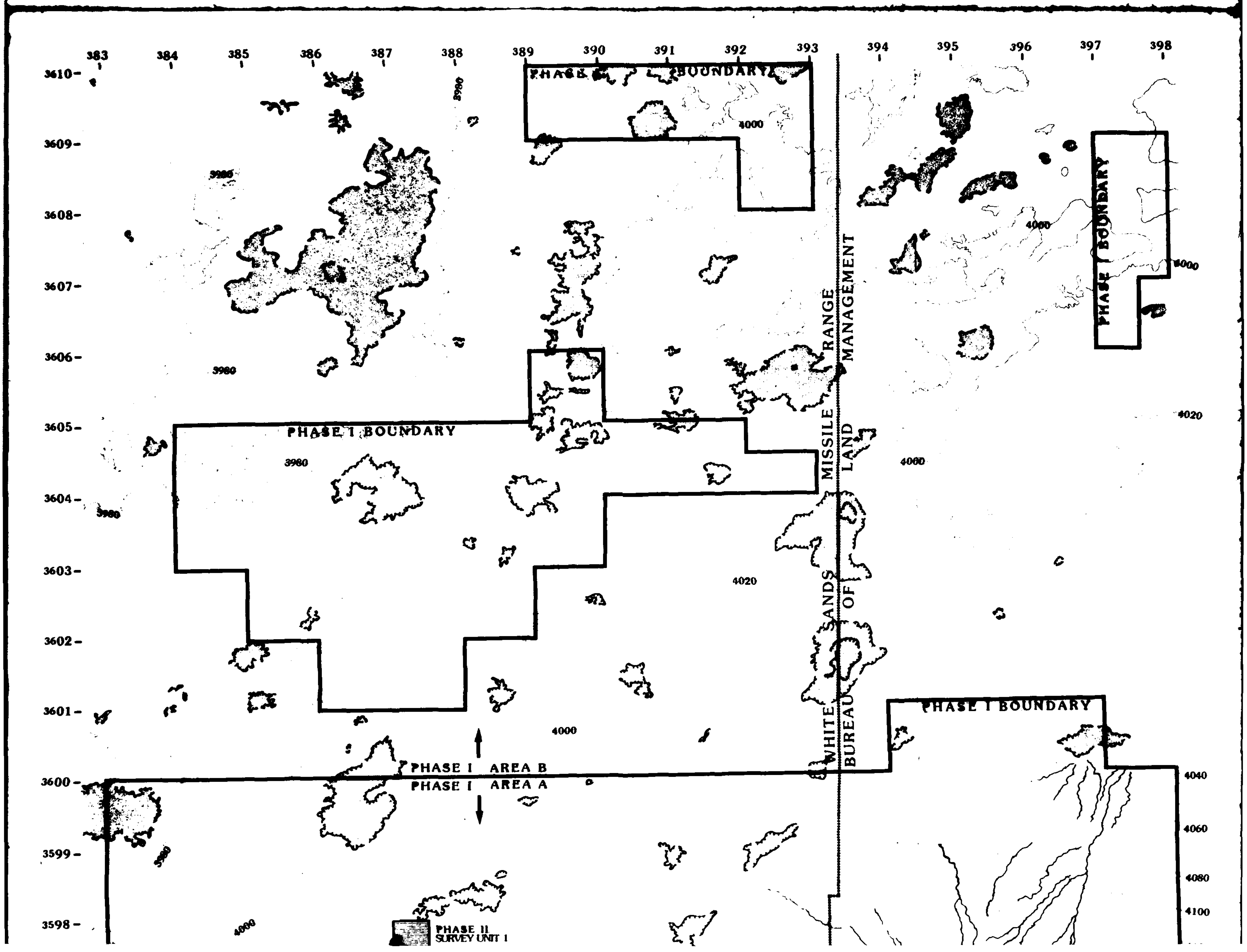
CAT	MAT	UL	UD	UR	UP	LL	LD	LR	LP	DA	FC	TC	S	O
108	1060	23	0	23	0	*18	*00	*10	*00	0	3	3	0	B
109	1032	23	0	0	0	14	*00	*00	0	30	2	2	0	
110	1032	0	0	33	0	*00	*00	*12	*00	0	3	3	0	B
111	1032	23	33	63	23	16	20	17	8	31	5	5	2	
†112	1210	32	33	0	0	22	18	0	0	25	5	5	1	
113	1032	0	23	22	0	0	19	*15	*00	10	5	5	1	
114	1052	0	0	12	0	*00	0	*04	*00	0	5	5	0	
115	1032	12	0	23	0	*06	*00	*22	0	52	2	2	0	B
116	1032	43	33	23	0	12	24	21	*00	30	1	5	1	
117	1032	22	32	22	0	*07	19	*11	0	0	4	4	0	
118	1052	0	33	0	0	*00	24	*00	*00	0	4	4	2	
†119	1233	23	33	23	0	18	26	9	0	30	5	5	1	B
120	1233	23	33	53	0	18	23	18	0	51	5	5	2	
121	1052	22	33	22	0	*14	*19	*12	0	51	6	6	0	
122	1052	0	0	0	0	0	0	0	0	0	1	3	0	
123	1032	0	12	22	0	*00	*05	*11	*00	0	1	1	0	
124	1233	23	33	43	0	24	22	19	0	34	5	5	0	
125	1072	42	33	0	0	*15	26	*00	*00	0	4	4	0	
126	1072	0	22	33	0	*00	31	29	*00	0	4	1	0	
127	1032	22	33	63	0	25	31	26	*00	41	5	5	2	
128	1032	22	33	23	23	13	23	15	15	40	5	5	2	
129	1052	13	0	32	33	*09	0	14	16	9	4	5	2	
†130	1032	53	33	23	0	31	29	21	0	35	5	5	1	V
131	1233	33	33	33	0	*09	*13	27	0	11	4	6	0	
132	1032	0	33	0	0	*00	22	*00	*00	10	5	1	1	

Key: CAT = catalogue no. in 3000 series, † = Paleoindian tool illustrated in Figure 17.2
MAT = Warren's material types
UL = use left, 1st digit is shape
- 1 = indeterminate
- 2 = straight
- 3 = convex
- 4 = concave
- 5 = beak
- 6 = sinuous

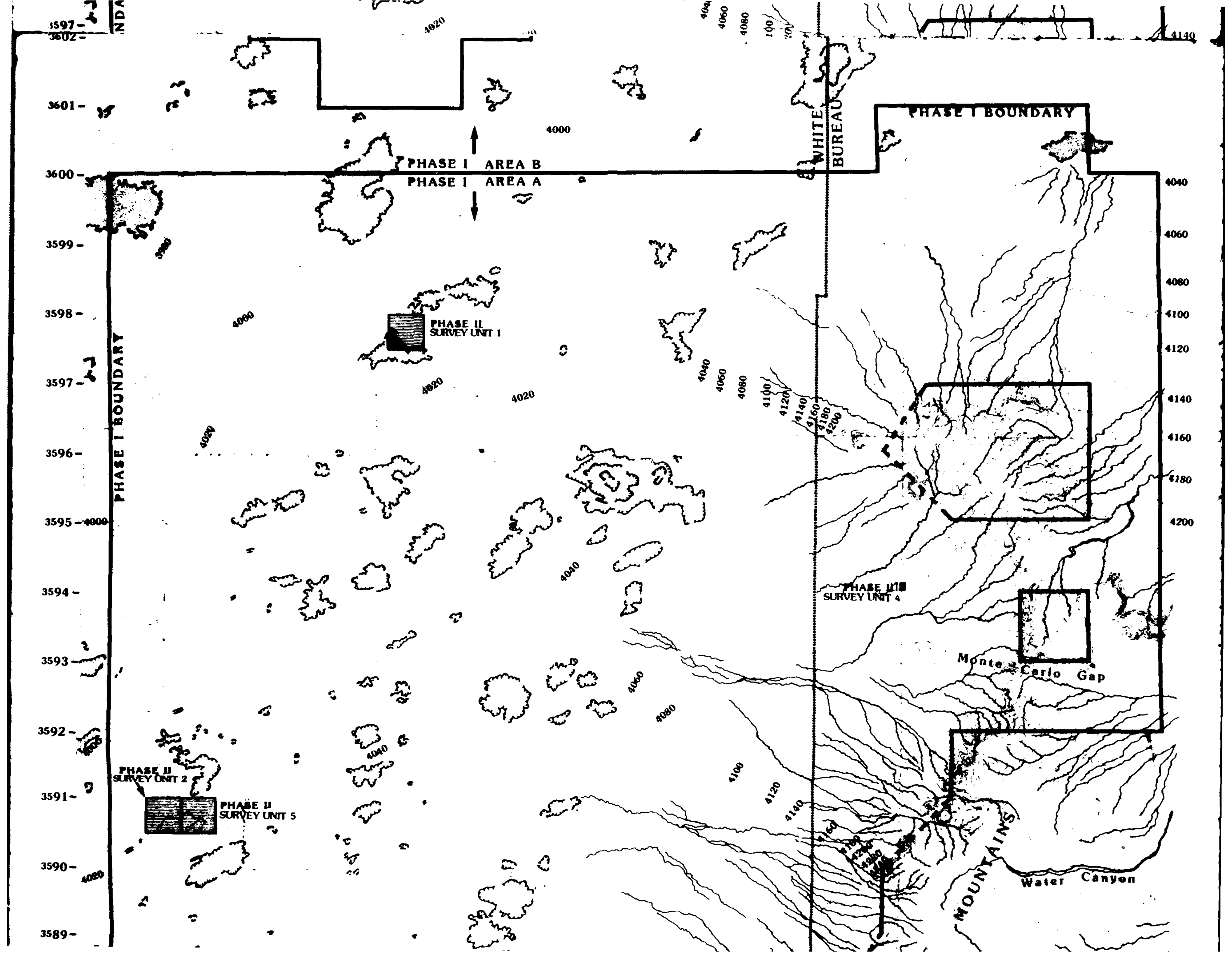
2nd digit is usage
- 1 = none
- 2 = knife, cutting
- 3 = scraping
- 4 = graver
- 5 = denticulate

UD = use distal, codes same as UL
UR = use right, codes same as UL
UP = use proximal, codes same as UL
LL = length left, * = broken edge
LD = length distal
LR = length right
LP = length proximal
DA = divergence or hafting angle
FC = flake condition
- 1 = unknown
- 2 = proximal
- 3 = medial
- 4 = distal
- 5 = complete
- 6 = lateral

TC = tool condition, codes = FC
S = no. of spurs
O = other
- B = burinated
- F = fire-crazed
- D = double scraping direction on one edge
- V = marginal retouch or use damage on ventral surface



PHASE I BOUNDARY
PHASE I BOUNDARY
PHASE I BOUNDARY
PHASE I BOUNDARY
WHITE SANDS MISSILE RANGE
BUREAU OF LAND MANAGEMENT
PHASE I AREA B
PHASE I AREA A
PHASE II SURVEY UNIT 1
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
3610
3609
3608
3607
3606
3605
3604
3603
3602
3601
3600
3599
3598
3980
4000
4020
4040
4060
4080
4100



PHASE I BOUNDARY
PHASE I AREA B
PHASE I AREA A
WHITE
BUREAU
PHASE II SURVEY UNIT 1
PHASE II SURVEY UNIT 2
PHASE II SURVEY UNIT 5
SURVEY UNIT 4
Monte Carlo Gap
MOUNTAINS
Water Canyon
3602
3601
3600
3599
3598
3597
3596
3595
3594
3593
3592
3591
3590
3589
4000
4020
4040
4060
4080
4100
4120
4140
4160
4180
4200

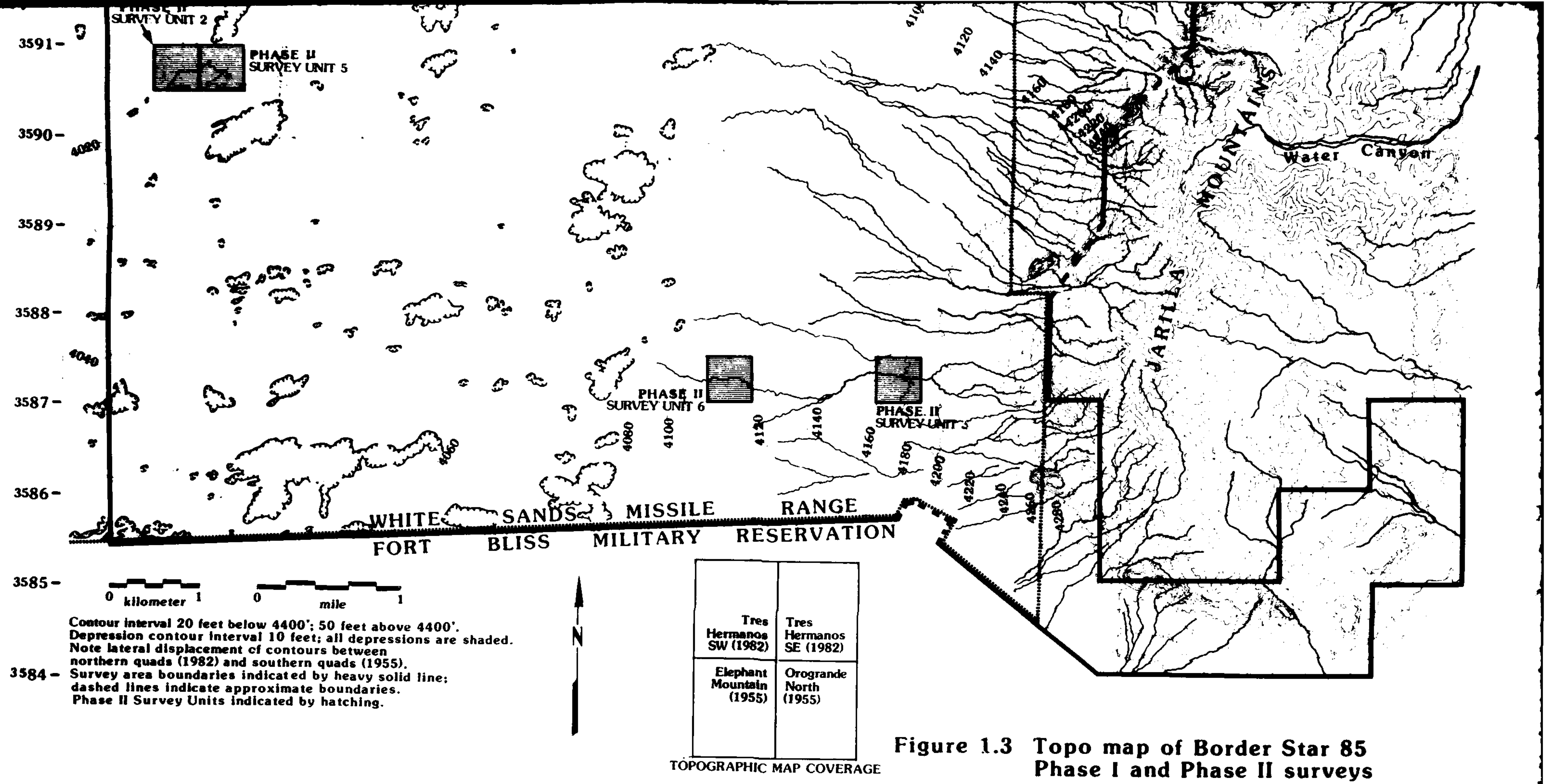
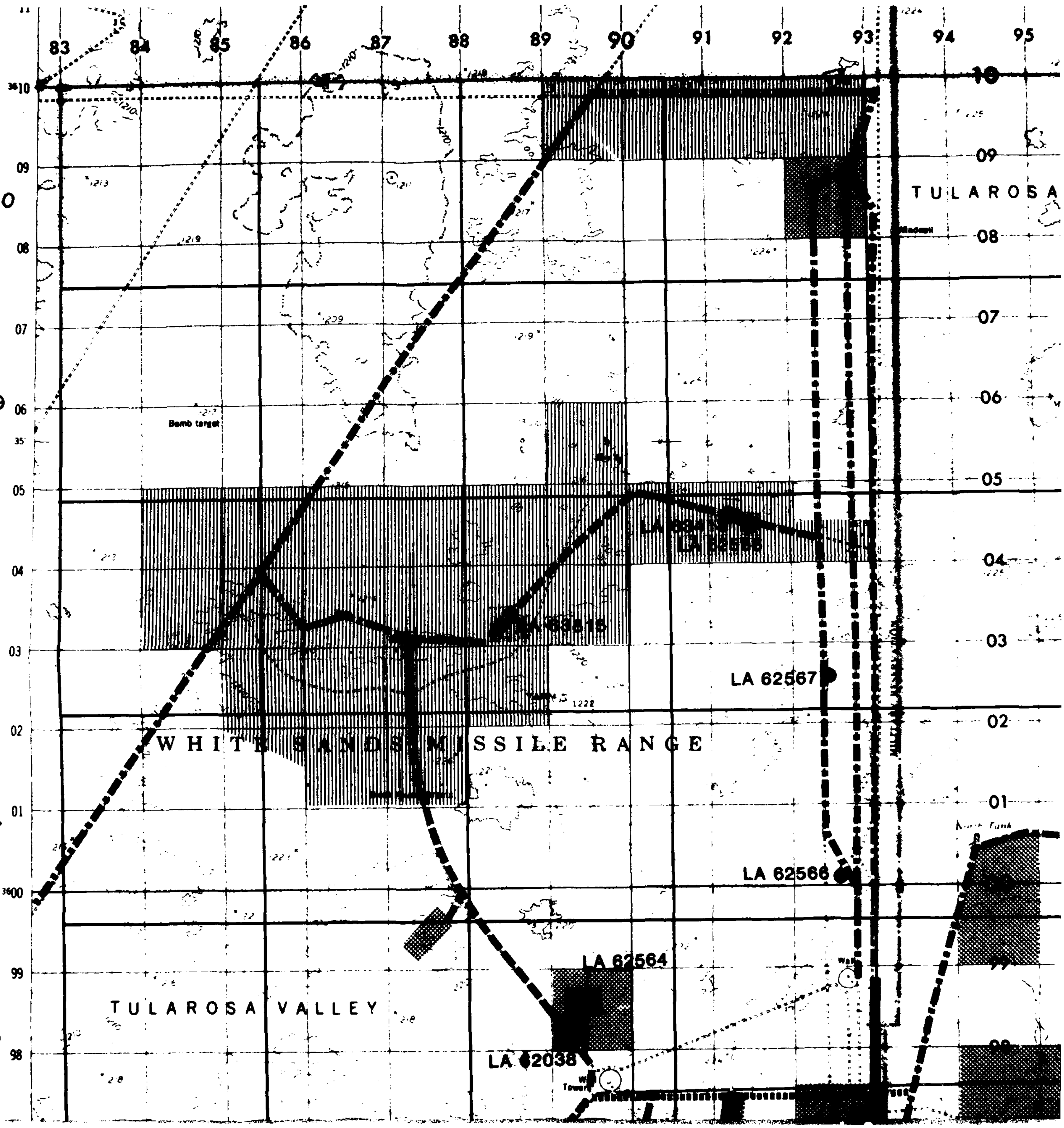
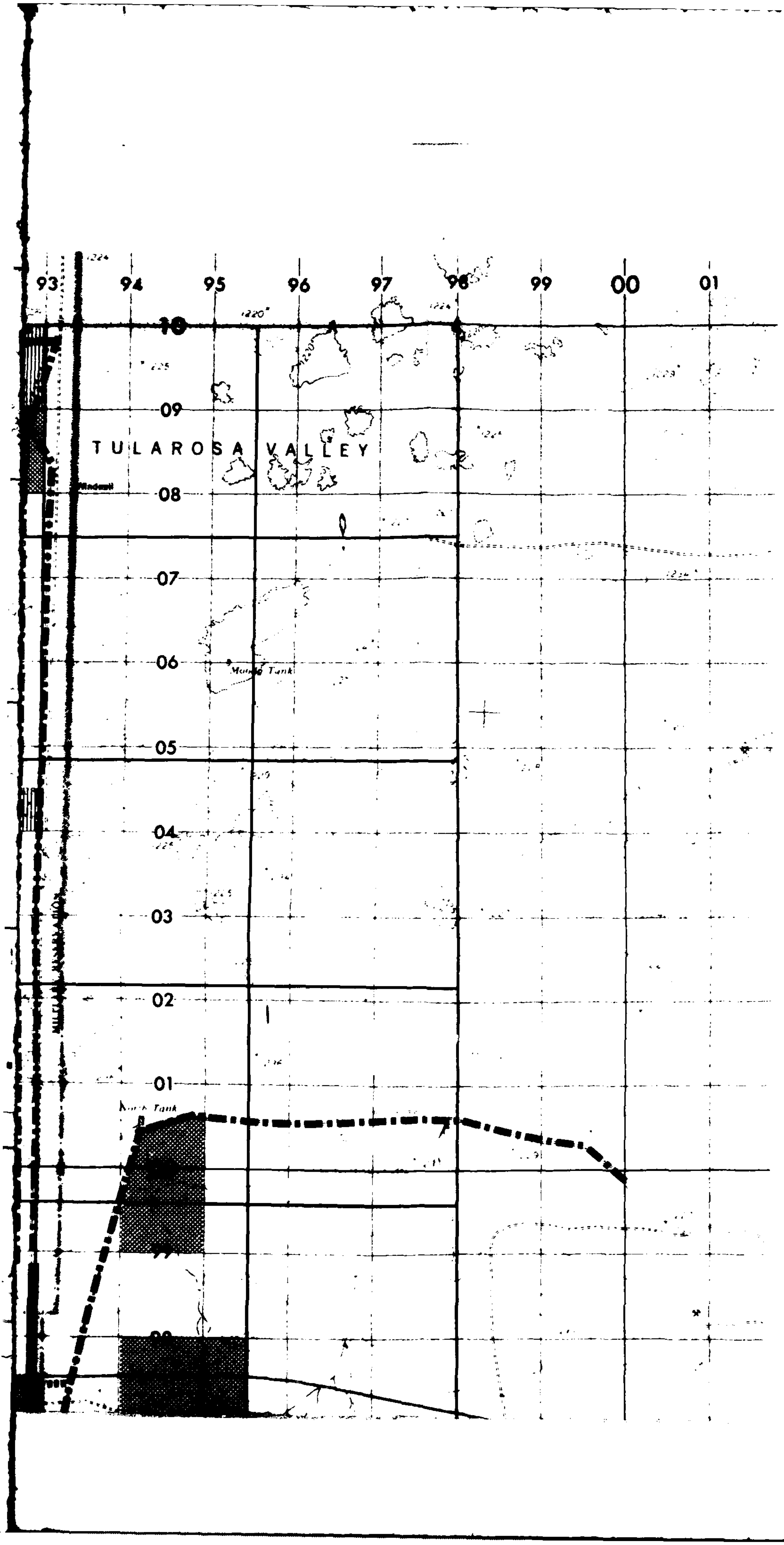
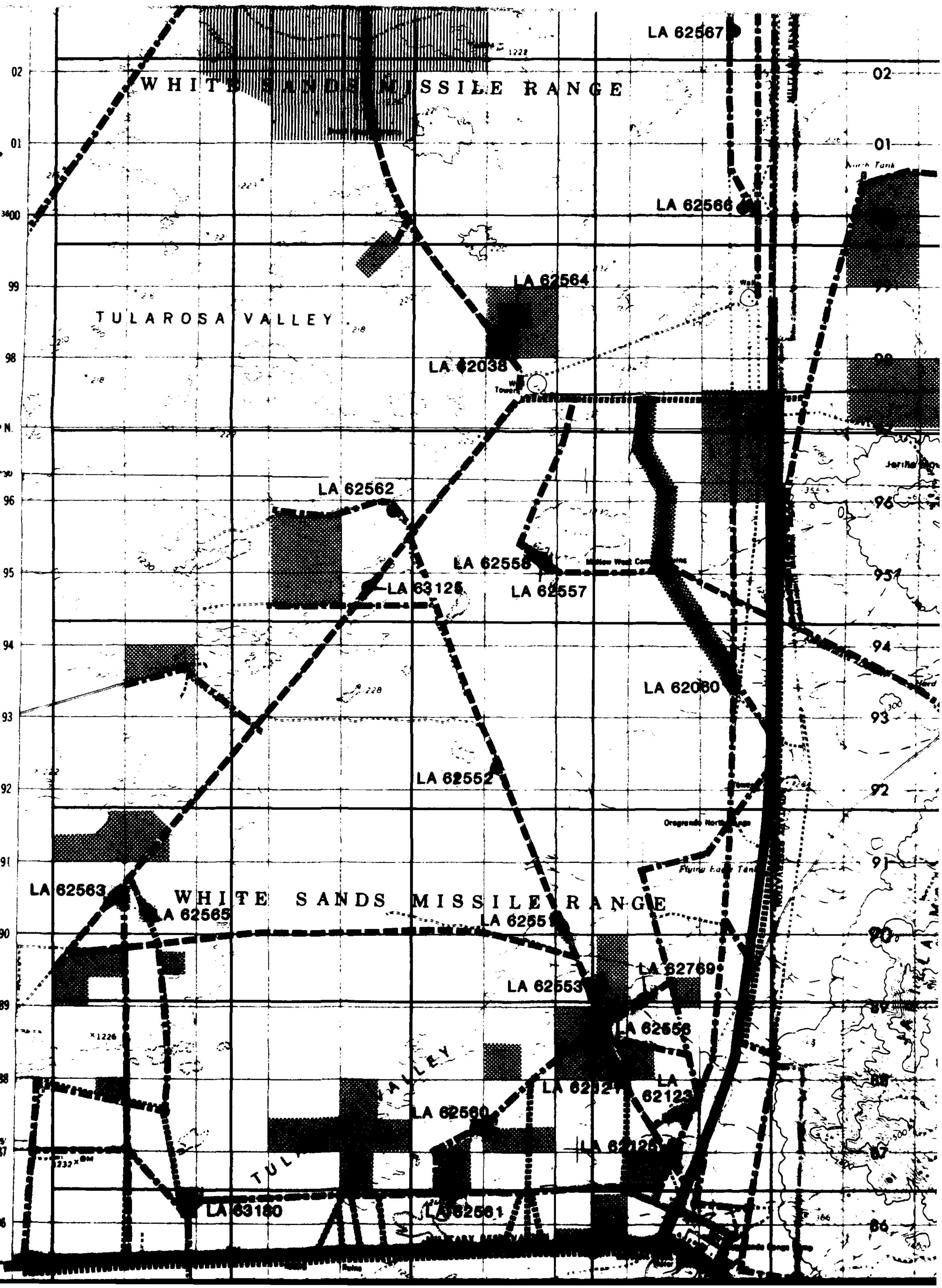


Figure 1.3 Topo map of Border Star 85 Phase I and Phase II surveys



83
84
85
86
87
88
89
90
91
92
93
94
95
10
9
8
7
6
TULAROSA
WHITE SANDS MISSILE RANGE
TULAROSA VALLEY
Bomb target
LA 63815
LA 62567
LA 62566
LA 62564
LA 62038


93
94
95
96
97
98
99
00
01
10
09
TULAROSA VALLEY
08
07
06
05
04
03
02
01



WHITE SANDS MISSILE RANGE
TULAROSA VALLEY
WHITE SANDS MISSILE RANGE
LA 62567
LA 62566
LA 62564
LA 62038
LA 62562
LA 62558
LA 63126
LA 62557
LA 62060
LA 62552
LA 62563
LA 62565
LA 62551
LA 62769
LA 62553
LA 62556
LA 62560
LA 63180
Oregrande North Range
Flying Eagle Tank
7
6
5
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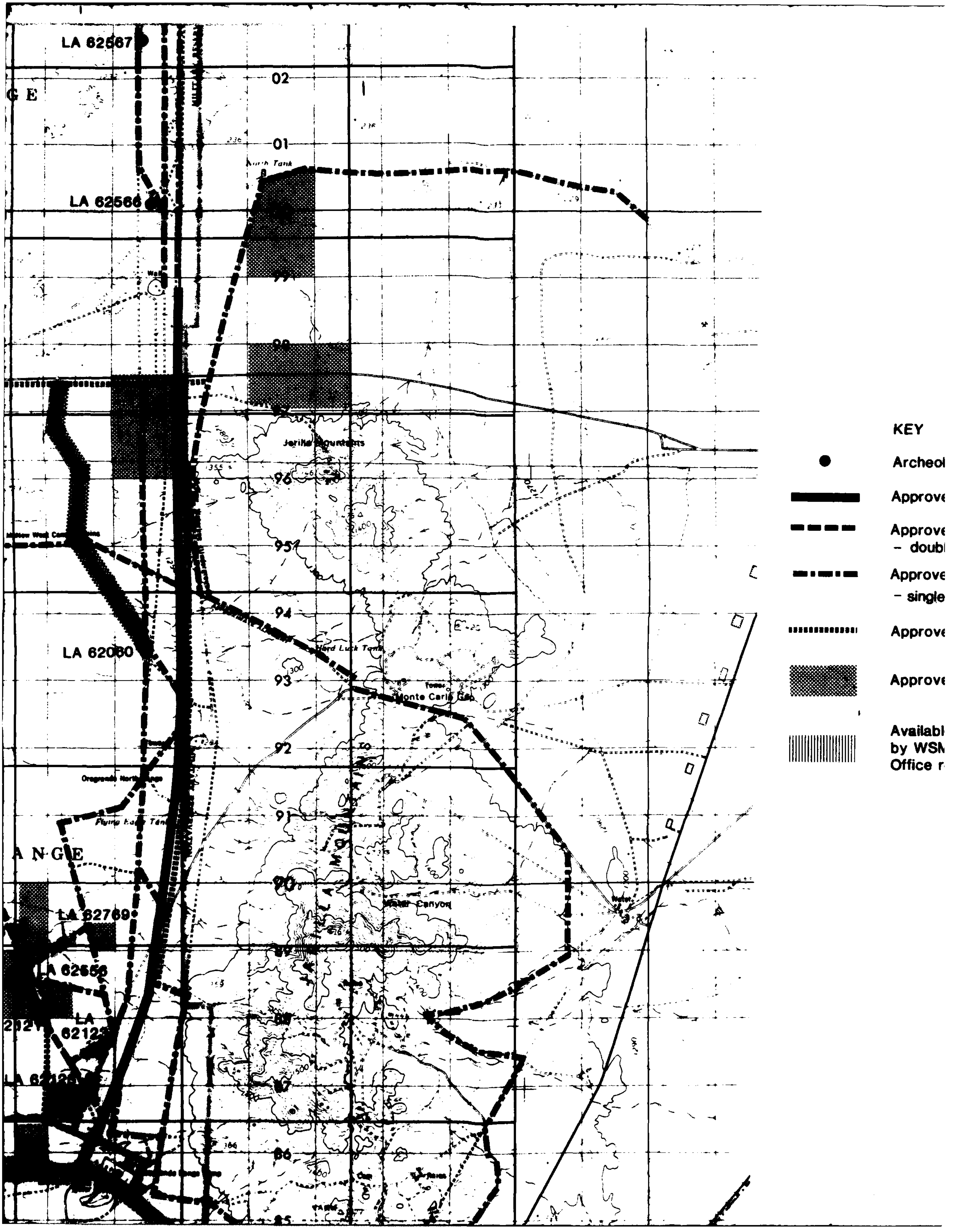
LA 62567
G E
02
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North Tank
LA 62566
98
Jarilla Mountains
96
95
94
LA 62060
Hard Luck Tank
93
Tower
Monte Carlo Gap
92
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A N G E
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LA 62769
Water Canyon
LA 62656
LA
62123
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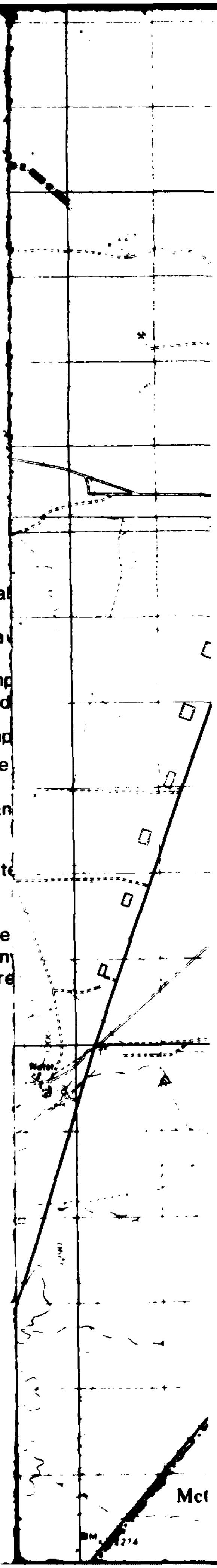
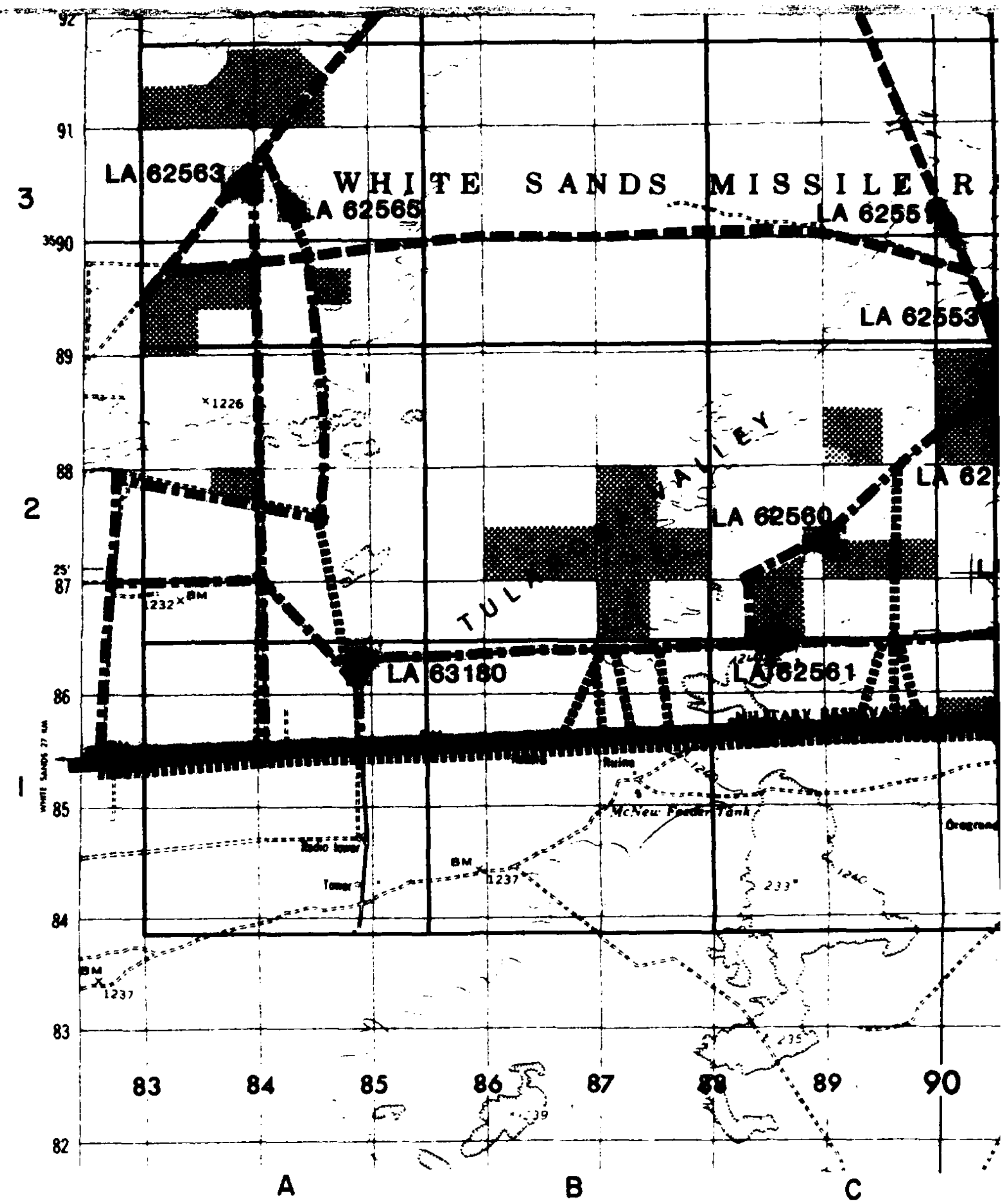


KEY

- Archeological site
- Approved paved road
- Approved unpaved road – double wide
- Approved unpaved road – single wide
- Approved tank trail
- Approved site area
- Available site area: approval by WSMR Enviornmental Office required



PHOTOGRAPHY & PHOTO REPRODUCTION BY

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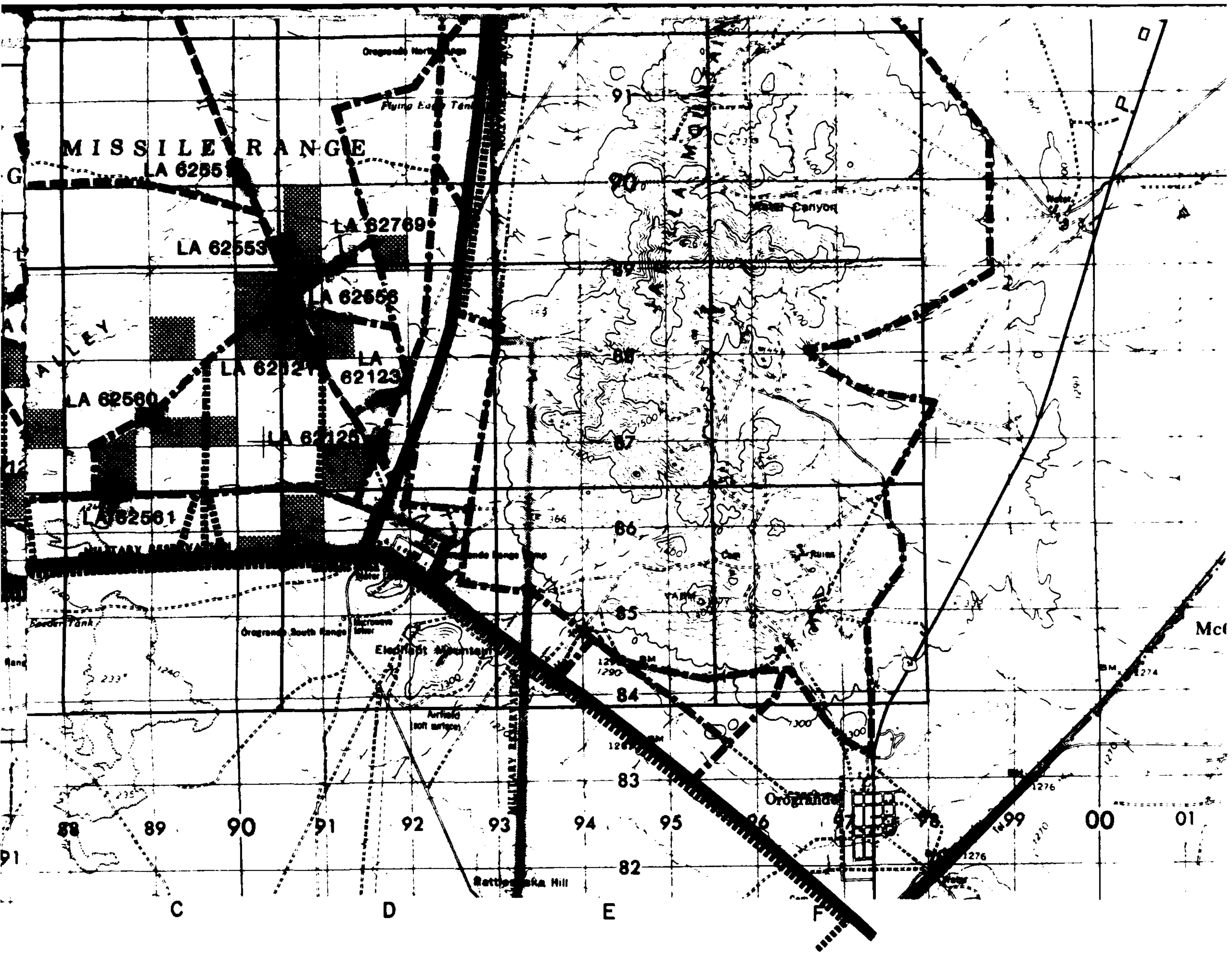
Figure A6.1 Border Star 85 Survey Area: Monitoring Program



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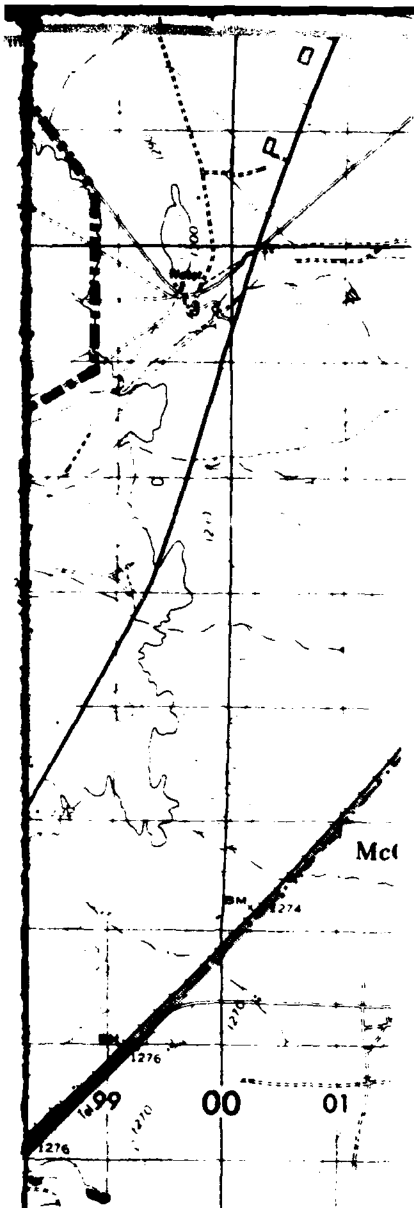
Office required



SOURCE:

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OROGRANDE RANGE ARCHAEOLOGICAL PROJECT

FOR

U. S. ARMY ENGINEER DISTRICT, FT. WORTH

CORPS OF ENGINEERS

FT. WORTH, TEXAS